THE Petroleum Engineer

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Next Month

The East Texas field has within the past few weeks taken on renewed activity. Installation of pumping equipment is proceeding at a rapid pace. How pumping problems are being met in this vast area will remain a featured subject of The Petroleum Engineer during forthcoming months. Comprehensive articles on every phase will enable the reader to keep abreast of latest developments and trends.

In the next issue an article by two widely-known authorities will analyze and discuss the character of loads on sucker rods. Other production articles will embrace the mechanics of oil well shooting as based upon practices in certain Kansas fields and repressuring practices in the oil fields of Illinois.

An article that will have a general appeal to all operating men in every division of the industry will be on photo-electric cells. This is a comparatively new development that has interesting possibilities.

W. L. Nelson, author of the popular series on modern pipestill heater design, will commence a new series on the subject of cracking. Another of the refinery articles will give the results of an exhaustive survey of refining clays.

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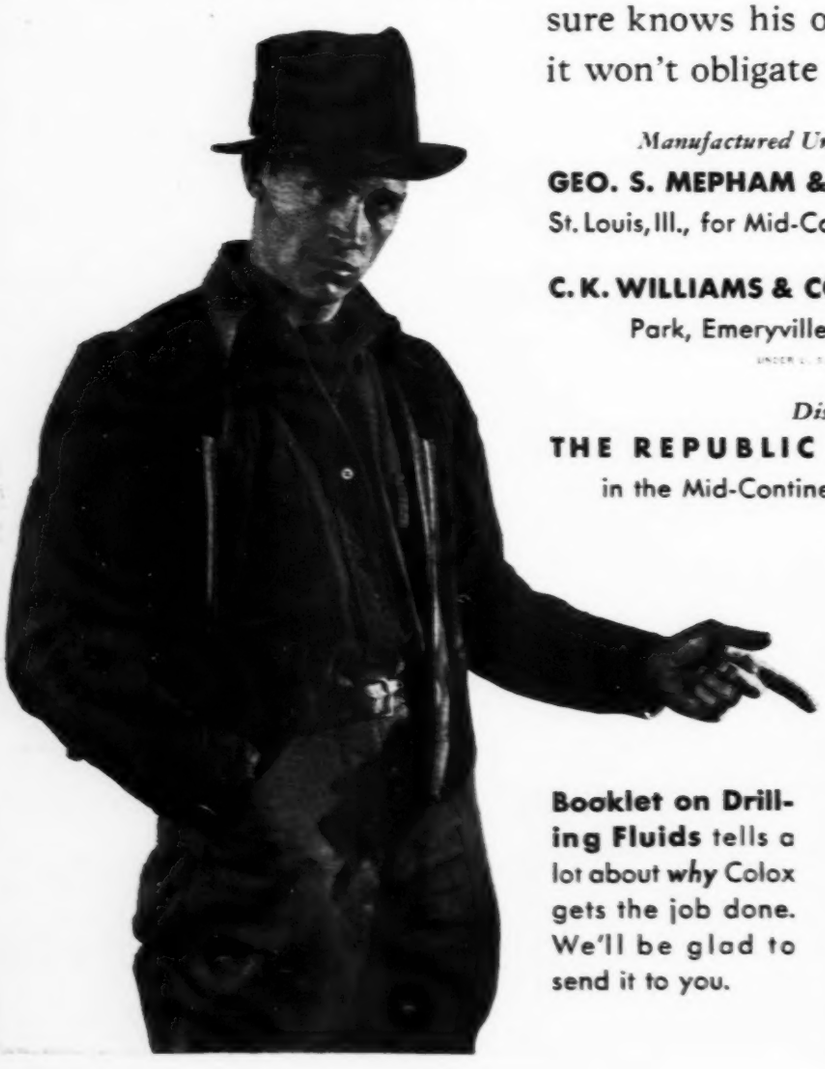

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The Course of Oil

By K. C. SCLATER

Salvaging the East Texas Field

WHEN the order was put into effect April 24 increasing the maximum daily allowable for the East Texas field to about 800,000 barrels, or fifteen per cent of the hourly potential flow, it was viewed with alarm and indignation by a majority of the operators there and by the oil industry in general. Subsequent events have proved that there were good grounds for the fear and resentment expressed. It was contended that this was too large an allowable if all the fields in the state, including East Texas, were to come within the state quota. It was also contended that this amount would prove too great a rate of withdrawal and would result eventually in incalculable harm to the field. There was a general feeling that the order was ill-advised, especially in view of the mass of data available to the Commission on the reservoir conditions in the East Texas field. From the Railroad Commission's standpoint it was confronted with the problem of writing a valid order that would be upheld by the Court and so intimated in defending the action it had taken in issuing the order. Disregarding the legal aspects of the problem and the fact that the market was flooded with oil, a consideration of the recent trend of producing operations in the field leaves no room for doubt that increasing the maximum daily allowable to more than 800,000 barrels was in error.

For fifty days, from April 24 to June 13, the field produced at a daily average rate of close to one million barrels—with what result? During the last few weeks many wells in the field have ceased to flow. Numerous others have shown signs of distress and have required some artificial means of stimulation to make them flow. There is abundant evidence that the rate of withdrawal from the field was too great, that the flowing life of the field was being shortened, and that the time for the installation of mechanical equipment for pumping or producing by artificial means was being hastened. To the producer it meant an increase in his future lifting costs. It was this item that suddenly aroused operators in the field to the fact that wells were much closer to the pumping stage than they had dared to believe. The effect was salutory, and when a hearing before the Railroad Commission at Austin was called on June 12, operators for once were almost unanimous in requesting a reduction of the field allowable. They all recognized the seriousness of the rapid downward trend of potential flow and bottom-hole pressures. Evidences of serious depletion were too palpable to be pushed aside on any pretense. Salvaging of the field by reducing the allowable was plainly necessary. As a result, effective midnight June 13, a new order was issued reducing the maximum daily field allowable to slightly less than 550,000 barrels or to ten per cent of the hourly potential flow. Although this new order is on the same basis as the preceding one, and a consideration of the acreage is still desired by many operators, the reduction in allowable was welcomed by the field in general. There appears to be little dissension from the new order.

Strict enforcement of the new order under this allowable no doubt will bring about a big improvement in conditions in East Texas field. However, the resulting harm that has been done during these fifty days in dissipating pressures in the field is obvious, and the pumping stage of the field has been brought several months nearer than otherwise would have been the case. Pumping costs in the field are prohibitive under existing crude prices.

At this moment the ultimate effect of the new order on reservoir conditions is still in doubt. Several perplexing angles now confront the field. Up until now the new marginal well law recently passed by the State Legislature has never been invoked. Whether or not it will be put into effect is problematical. There is a fear, however, that because many wells in the field have gone on the pump and will not flow without some artificial stimulation they may be allowed to produce only twenty barrels a day under the marginal well law, instead of the allowable arrived at by potential flow tests.

At least one lesson should be learned from what has occurred in East Texas field. As soon as a new field is developed a well-spacing program should be decided on and strictly adhered to thereafter. Only in this way can equities in prorating flush fields be reconciled and made workable to the satisfaction of all. Lack of a well-spacing program and its enforcement, as has been stated in these columns at various times, has been at the root of the trouble in the East Texas field. While it is conceded that the greater the number of wells the larger the recovery, this in itself is no justification for close spacing. There is an economic limit that will give the greatest economical recovery commensurate with the capital invested. In this regard it must be remembered that the price of oil is an important factor entering into any well-spacing program and is one quite apart from the underground physical factors of the reservoir.

Had the field been allowed to continue at its high rate of flow it is quite probable that supply manufacturers would have, within a very short time, found themselves unable to meet the demand for equipment. As it is, many manufacturers are swamped with orders for several months to come and their present facilities taxed to fill the orders already on hand. Even with the reduced allowable it is expected that the demand for pumping equipment will gradually increase and that manufacturers will thereby have a better opportunity to supply the needs as they arise.

« « « HIGHLIGHTS IN OILDOM » » »

East Texas Allowable Reduced

Effective midnight, June 13, the Texas Railroad Commission adopted 550,000 bbl. as the daily allowable for the East Texas field. The previous allowable had been 826,000 bbl. The new allowable is based on 10 per cent of the well hourly potential, whereas the preceding order had as its basis 15 per cent of the well hourly potential.

●

Texas and Oklahoma Proration Law Valid

Proration orders as enforced in East Texas by the Texas Railroad Commission were declared valid in a bench decision rendered at Fort Worth by a three-judge federal court. All previous orders of the commission covering proration enforcement in East Texas had been stricken down when exposed to attacks in federal court.

In Oklahoma, the third legal attack on the state's new proration law failed to defeat enforcement when a three-judge federal court dismissed an injunction suit.

●

Federal Control Situation

Legislation intended to establish federal control over the oil industry has been presented to Congress in the form of a revision of the proposed bill submitted to the President several weeks ago. While the revised bill does not provide for an oil dictator, its provisions are so strongly worded as to leave little chance for freedom of action.

●

Tomball Well Spacing Order Issued

The Texas Railroad Commission hopes to prevent close well spacing conditions in the new Tomball field of northern Harris County. Close well spacing in East Texas has been the principal difficulty in establishing equitable proration in the field. Although only one well has been completed at Tomball, the commission has issued an order requiring that wells located in the pool be drilled 466 ft. from lease lines and 933 ft. apart. This means one well to every 20 acres. In attempting to control development of the field in this manner the commission has for the first time assumed an interest in a field before it has become actively developed.

●

Available Oil Scarce in Oklahoma

With many Oklahoma producers, particularly at Oklahoma City, refusing to sell oil at the present low prices there is a current scarcity of crude oil in the state. Several purchasers have asked the State Corporation Commission for permission to buy additional crude. The Carter Oil Company renewed its request for 25,000 bbl. additional daily from the Oklahoma City field and for 20,000 more from other sectors and notified the commission that unless such permission was granted it would turn to East Texas for its supply. The company during May ran only 3000 bbl. daily from Oklahoma City and on some days had no oil at all.

Ordering Pumping Equipment for East Texas

The past few weeks have witnessed a heavy demand for pumping equipment from operators in the East Texas field. Dissipation of the field's bottom-hole pressure during the last seven weeks when the field averaged close to a 1,000,000-bbl. daily output, has caused many wells to cease flowing naturally. Some estimates are that from 3500 to 5000 wells will require pumping equipment within the next six months and that within another 18 months the majority of wells in the field will need artificial means for raising the oil to the surface.

Many operators desire to avoid the rush buying period when it may be impossible to obtain delivery of equipment and some unusually large orders for pumping machinery have been placed recently.

●

Oil Industry Considering Code of Ethics

Representatives of 33 oil producing associations and representatives of the American Petroleum Institute are in meeting at Chicago as this is written. This is the first of a series of conferences designed to develop a code of practices for the oil industry. It is hoped these meetings will result in the adoption of a set of rules under which the industry may run itself and at the same time end destructive competition within the oil business.

●

East Texas Water Wells Increase

A Texas Railroad Commission report dated June 10 shows that 317 wells in the East Texas field are making water, ranging from a trace to as high as 100 per cent. This compares with 187 wells on March 15 and 241 on May 18. The wells listed as making water are to be found in every sector of the field.

●

Price Increase Announcements

Sinclair Prairie Oil Company led the major purchasers in establishing higher crude prices when it reinstated its posted schedule in existence prior to the April cuts. The new gravity schedule has a maximum price of 52 cents per barrel. The Sinclair Prairie schedule carries a flat price of 50 cents per bbl. for East Texas crude. Earlier price increases had been made in scattered areas by smaller purchasers.

●

Propose Additional Federal Gasoline Tax

The Senate Finance Committee has recommended that an additional half a cent a gallon federal tax on gasoline be imposed on motorists to raise money to stand the cost of financing the $3,300,000,000 appropriation that goes with the Industrial Recovery Bill. If the measure is enacted it will mean the gasoline tax will pay $1,068,865,000 of the cost of financing the bill during the 15 years it is to be in effect, of which only $400,000,000 will be spent on highways.

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3. Provides up to 33⅓% more screen area.

4. Provides a wide margin of safety against drilling into bottom hole water in a saturated oil sand, as you need only penetrate the sand ½ to ⅔ as deep as in reduced hole practice to get the same drainage surface.

5. Eliminates expense of hauling, making up and running drill stem inside the production string to drill cementing plugs. (The plugs may be drilled by the flow string of tubing.)

6. Allows the well to be put on production within two hours after the cementing plugs have been drilled.

7. Materially increases useful life of well.

8. Allows the setting of screen or perforated liner of the same size as production string, thorough washing of muck and cavings from behind the screen and cementing the casing—in one continuous operation.

9. When used in combination with HOWCO Cement Lining for Screens or Perforated Liner it gives utmost assurance that the space between the screen and sand is thoroughly clear of heavy muck, cavings, etc.

10. Permits setting larger insert screen, if necessary, at later date.

11. Eliminates expense of cutting and fishing of screen or perforated liner when necessary to deepen well—a saving which often amounts to $2500.00 per well.

12. Less energy required for the oil to travel from the sand into the hole, permitting greater freedom of flow from the sand into the well during the pumping stage—(actual profit on original investment is very often dependent upon economically producing the last few thousand barrels per acre.)

13. With the same size hole and screen in the sand as in reduced hole practice, allows original investment per well to be materially reduced by running casing of the same size as screen.

14. With the same size casing and considerably larger hole in the sand than in reduced hole practice, it still allows a slight reduction in original investment, but materially increases ultimate profit.

In other words:

The Full Hole Cementer accomplishes, in a modern manner, an aim almost as old as the oil industry itself — larger drainage surface — accomplished at the least original cost and yielding greater ultimate profit.

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OIL WELL CEMENTING CO.

Duncan, Oklahoma

LATEST ACTIVITIES IN THE OIL FIELDS

DURING the past month additional discoveries further enlarged the Texas Gulf Coast region's already huge potential production possibilities. Indications are that the Coastal territory will for at least another year be a most active section from a development standpoint.

●

Recently there were two important developments in the Conroe district of the Gulf Coast. A new oil pool was opened in northern Harris County and the second producer in Polk County was completed. These new strikes increased the interest of oil operators in this section and the wildcat play has been greatly stimulated.

●

—Magnolia Petroleum Company and Humble Oil & Refining Company's Kobs 1 has proved productive the Tomball region of Harris county. This wildcat producer is located 17 miles southwest of Conroe and 20 miles north of Houston. It made an initial flow of 69 bbl. per hr. through a ½-in. choke and is producing from the Cockfield formation, which also is productive at Conroe. While only one well has been completed at Tomball, an active drilling campaign is anticipated as lease expirations in the vicinity call for the drilling of 30-odd wells before May, 1934.

●

In Polk County, the outlook for a major pool in the Livingston district was strengthened by the completion of Dick Schwab's test for 1007 bbl. through a ½-in. choke. The Shell Petroleum Corporation discovered production at Livingston last month and the discovery well is flowing 800 bbl. daily through a ½-in. choke from the Cockfield formation. This output is considerably below its initial flow and, prior to the drilling in of the Schwab test, some operators were discounting the extent of the productive region.

●

The importance of Refugio and Victoria counties and the immediate surrounding territory of the South Texas Gulf Coast as a potential oil reserve was further emphasized with the opening of two entirely new fields. One of these important strikes is located nine miles northeast of Refugio and is making 22 bbl. per hour through a ¼-in. choke. The Victoria county well is 15 miles northwest of the McFadden district and is spraying high-gravity oil. It showed 1600 lb. pressure on a 1/32-in. choke. No official gauge of the well has been made as this is written. It is expected that the Refugio County new pool will be the scene of a line fight, which will bring about the immediate drilling of a number of wells, making the discovery one of the most important in South Texas. Already 25 tests have been commenced.

●

Other South Texas areas continue to be busy and any improvement in the posted price for crude oil is expected to cause an increase in drilling. The North Government Wells field, Duval county, continues to be extended north. Two more producers on outpost locations have added to the north producing area. The Serpentine formation possibilities of Bastrop County are receiving increasing attention and some interesting developments are expected in the near future.

●

Discovery of oil in the Eocene formation at 10,915 ft. in North Kettlemen Oil & Gas Company's record depth wildcat well is being regarded by many operators as one of the most important California developments in several years, and it may mean that deeper production underlies many of the older fields. The well was allowed to flow a few minutes, but no gauge was made of the production. The pressure was very high. Stuck drill pipe at 10,944 ft. has stopped drilling considerably short of the level at which a production test was to have been made. The drill pipe string was shot loose at 10,924 ft. and the hole is being conditioned for a production test.

●

Two completions located five miles apart almost due north and south have extended the producing limits of the Converse field of Sabine Parish, Louisiana, 2½ miles south and ¾ mile northwest. The field was already four miles east and west and is now five miles north and south.

●

The Wentz-Lucien area of southwestern Noble County, most promising new area in Oklahoma, received its second gusher with the completion of Shell Petroleum Corporation's ¾-mile southwest extension test for 1140 bbl. in five hours.

AVERAGE CRUDE OIL PRICES

California		Arkansas	$ .25
Playa Del Rey	$ .69	Louisiana	
Coalinga	.49	North Louisiana	.25
Long Beach	.75	Gulf Coast	.30
Montana	.65	Illinois	.47
Wyoming	.25	Kentucky	.42
Colorado	.25	Indiana	.25
New Mexico	.20	Ohio	
Texas		Lima	.55
North Central	.25	Wooster	.50
Panhandle	.20	Michigan	.75
West Texas	.20	Pennsylvania	
Gulf Coast	.30	Bradford	1.37
Darst Creek	.23	Corning	.50
East Texas	.25	West Virginia	1.02
Kansas	.25	Canada	1.75
Oklahoma	.25		

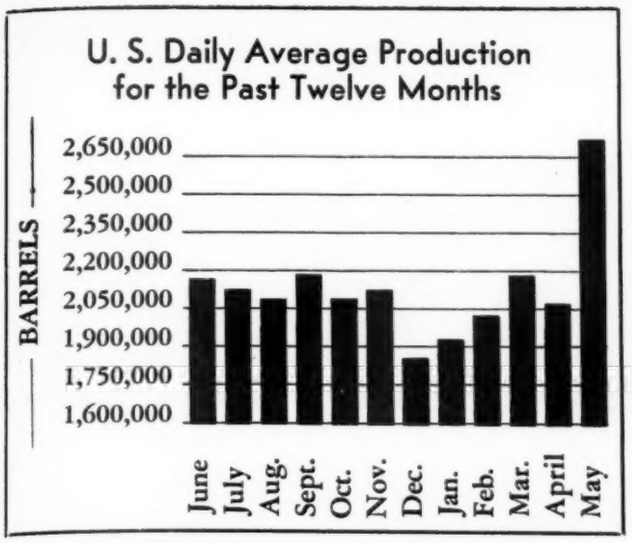
DAILY AVERAGE PRODUCTION[1]

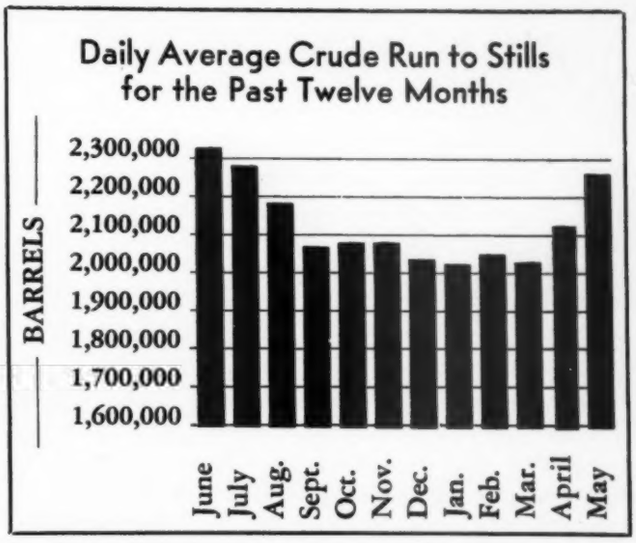
(Figures in Barrels)

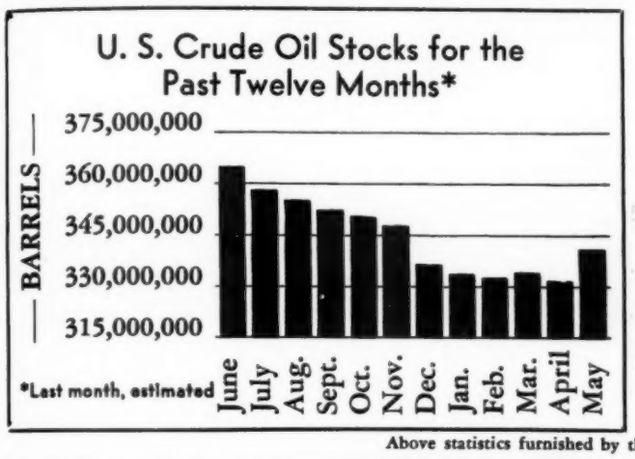
	Week Ended May 27, 1933	Week Ended April 22, 1933	Week Ended May 28 1932
Oklahoma	383,350	377,450	399,150
Kansas	105,650	115,250	96,900
Panhandle Texas	44,150	43,800	51,500
North Texas	47,850	52,150	51,550
West Central Texas	19,800	23,300	25,450
West Texas	160,500	159,750	183,900
East Central Texas	58,350	58,250	56,900
East Texas	814,500	*	334,300
Conroe	78,000	41,150	
Southwest Texas	48,500	48,900	54,600
North Louisiana	26,400	29,900	29,250
Arkansas	29,950	30,200	34,300
Coastal Texas (Not including Conroe)	115,000	115,000	113,650
Coastal Louisiana	41,450	42,200	33,900
Eastern (Not including Mich.)	89,050	87,600	108,250
Michigan	16,100	16,850	19,200
Wyoming	27,400	29,300	38,200
Montana	5,900	5,050	8,650
Colorado	2,550	2,350	3,300
New Mexico	36,100	36,250	36,700
California	484,000	480,800	489,700
TOTAL	2,634,550	1,795,500	2,169,400
Texas	1,386,650	542,300	871,900

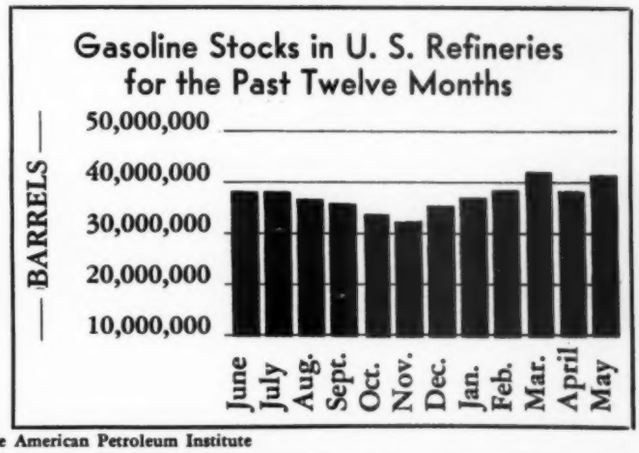
* East Texas shut in.

[1]Production figures furnished by the American Petroleum Institute.









Above statistics furnished by the American Petroleum Institute

Summarized Operations in Active Fields for May, 1933

Fields	Completions	Producers	Locations	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas									
East Texas	102	101	95	49	49	3600	2	40	Rotary
Duval County	13	9	36	7	40	2300	2	22	Rotary
Conroe	64	63	52	14	39	5200	2	38	Rotary
Oklahoma									
Oklahoma City	6	6	4	1	6	6500	3	39	Rotary
Kansas									
McPherson	21	5	9	3	21	2900-3400	2	38	Rot.-Cab.
Ellsworth Arch	6	3	5	7	27	3300	4	37	Cable
Harvey County	13	12	3	4	26	3450	2 or 4	37	Rot.-Cab.
California									
Kettleman Hills	3	3	2	2	10	8300	3 or 4	40	Rotary
Long Beach	3	3	9	1	16	7000	3	26	Rotary

Field Activities by States for May, 1933

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1932 (In Barrels)
	May	April	May	April	May	April	May	April	May	April	
Arkansas	7	3	1	1	6	3	10	16	28	26	11,907,000
California	30	22	26	20	44	29	13	16	112	120	178,128,000
Colorado	1	8	0	1	....	....	7	8	56	56	1,177,000
Illinois	1	1	0	0	....	....	2	1	10	10	4,661,000
Indiana	7	16	6	12	....	....	2	2	51	53	804,000
Kansas	57	55	37	37	38	69	25	29	112	89	34,300,000
Kentucky	14	9	8	5	....	....	2	3	46	41	6,264,000
Louisiana	59	41	25	25	76	48	48	39	141	124	21,478,000
Michigan	28	14	22	9	29	29	43	50	74	75	6,729,000
Mississippi	6	3	2	0	....	....	2	3	14	15	Gas. Prod.
Montana	0	2	0	2	....	....	3	4	31	30	2,449,000
New Mexico	3	4	3	3	....	....	6	6	56	59	12,511,000
New York	2	4	2	3	....	....	2	2	12	9	3,501,000
Ohio	46	46	34	34	....	....	30	31	105	109	4,597,000
Oklahoma	102	89	65	61	91	93	69	87	216	286	152,621,000
Pennsylvania	47	35	41	25	302	470	28	30	85	93	12,403,000
Texas	456	466	299	332	....	....	143	195	551	694	311,069,000
West Virginia	21	23	12	19	....	....	9	14	28	34	4,472,000
Wyoming	2	1	0	0	....	....	9	8	57	58	13,359,000
Total	889	842	581	589	580	741	453	544	1785	1981	781,845,000

PROGRESS OF MAJOR PIPE LINE WORK

By WARREN L. BAKER

WHILE no important major pipe line projects were announced during the past month, many Mid-Continent transporting companies are enlarging their gathering systems, a few of these companies actually being in need of additional crude to supply their demand.

●

Several newly discovered fields without pipe line outlets are soon to be provided with such facilities. Humble Pipe Line Company is laying the first outlet to the new Tomball field in northern Harris County, Texas. This is a 13-mile 6-in., 8-in. and 10-in. line that will run from the company's Satsuma pump station on its trunk line to a point about 2½ miles southeast of the discovery well. The line will be ready for operation by July 1. Magnolia Petroleum Company, co-owner with the Humble in the Tomball discovery well, is also contemplating the construction of a line from this field. Magnolia's line, it is expected, will be laid over an 18-mile route northeast of the field where it will tie into the company's main line at Richards Station.

●

A much needed pipe line outlet is being provided for the shallow Moca field in northeastern Webb County, South Texas. Duval Pipe Line Company is laying a 4-in. line that will extend 45 miles east across Duval County, through the Government Wells field to the Tex-Mex Railroad between San Diego and Benavides. Capacity of this unit will be 10,000 bbl. daily.

●

Shell Pipe Line Company has started work on a 6-in. oil line from the Wentz-Lucien pool in Noble County, Oklahoma. It will tie in with the company's double 6-in. line running from Cushing to Tonkawa at Goldsby Station in northern Payne County, approximately 26 miles due east of the pool. This will give the pool its second outlet.

●

Humble Pipe Line Company hurriedly constructed a total of 40 miles of 4-in. lines in the East Texas field in order to relieve its gathering system of excessive pressures as a result of the large amount of oil handled in the pool when the field allowable was above 800,000 bbl. daily.

●

Barnsdall Oil Company, important producer in the East Texas field, will become a permanent buyer of oil in the district. The company is building a gathering system in the northern part of the field and is also building a 25-car loading rack.

●

The Pure Oil Pipe Line Company has commenced construction of a new pump station in Porter Township, Midland County, Michigan. The station will be equipped with a 100-hp. unit and, together with the new 6-in. line from the station to its Greendale Township tank farm, the company will have a unit of 12,000 bbl. per day capacity.

The Pan American Refining Company has definitely decided upon the erection of a 25,000-bbl. refining plant at Texas City, Texas. It is understood that its sister company, the Stanolind Pipe Line Company, will transport crude oil to the plant. This will necessitate the construction of about a 35-mile extension to the pipe line system of Stanolind. The latter operates a 10-in. line with 8-in. loops from Mexia to Sinco, near Houston. The construction of this line is expected to be started before fall.

●

It is rumored that the Humble Pipe Line Company will also increase the capacity of its line from the Conroe field in Montgomery County to the Houston shipping channel in order to handle additional crude from that district.

●

Eight miles of 6-in. pipe is being laid along the original line of the Great Lakes Pipe Line Company, near Skaitook, Oklahoma. This announcement follows the purchase of a four per cent interest in the company by The Texas Company. A 6-in. line from The Texas Company's West Tulsa refinery to the Great Lakes line, a distance of about one mile, has been completed. The Great Lakes Company is considering the laying of a 28-mile pipe line from The Texas Company's refinery at Lockport, Ill., which will enable it to make delivery of gasoline into Chicago, Milwaukee and to a lake terminal for tanker shipment. Additional pumping units are also being installed on the line.

●

Southern California Gas Company is planning construction of two pipe lines totaling approximately 87 miles in Kings and Tulare counties, California. The lines would be extensions of mains now owned and operated by the company in that vicinity.

●

A rumored project is one to pipe natural gas from Alberta to Winnipeg, Manitoba, Canada, and intermediate communities. It is being contemplated by the Fabyan Utilities Syndicate of Vancouver, British Columbia. It is understood tentative arrangements have been made for gas production.

●

Truman-Smith Construction Company, El Dorado, Kan., and Meador & Whitaker, Burkburnett, Tex., contractors on the Sinclair Prairie Pipe Line Company's 140-mile 12-in. oil line from Teague, Texas, to a point north of Houston, are making good time. The work consists of taking up an old line and relaying it in the new location. The project is approximately 60 per cent completed.

●

Ford, Bacon & Davis, Inc., contractors on the Pure Oil Company and Sun Oil Company 60-mile 6-in. gasoline line from Toledo, Ohio, to Detroit, Mich., expect to finish the line early in July.

THE MONTH'S ACTIVITIES IN REFINING

By F. R. STALEY

Per Cent Refining Capacity Operated

Eastern Division 68.0 Per Cent **Central Division 66.4 Per Cent** **Western Division 39.8 Per Cent**

ONE of the largest new refinery projects to be announced in recent years will get under way in the near future, according to officials of the Pan American Petroleum and Transport Company. The Pan American Refining Corporation has been granted a permit by the State of Texas. The new concern is a subsidiary of the Pan American Petroleum and Transport Company, which, in turn, is controlled by the Standard Oil Company of Indiana.

●

The Pan American Refining Corporation will construct a 25,000-bbl. daily capacity refining plant at Texas City, Tex., on the Gulf Coast. Ultimately the capacity of the refinery is expected to be raised to 50,000 barrels. The company, until its decision to build at Texas City, was considering building along the Houston ship channel. The equipment will provide for well-balanced cracking operations, a power plant and other modern facilities, including storage. The plant has been designed by the manufacturing departments of the Pan American Company and the Standard of Indiana. Contracts have been let for part of the new equipment. M. W. Kellogg Company will erect distillation and cracking facilities under contract. The Standard of Indiana, through its subsidiary, the Stanolind Oil & Gas Company, has large production reserves in the East Texas field.

●

A number of new refineries will be erected in Canada in the near future. The Bell Refining Company, Ltd., will increase the capacity of its plant at Calgary. T. B. Jones will build a small refinery at Moose Jaw. The Hydrogas Refining Company plans a plant at Toronto.

●

Another important refinery activity announcement comes from Pennsylvania, where the Wolverine Empire Refining Company plans improvements to its Reno, Pa., refinery. Plans embrace a complete modernization of the refinery's distillation equipment, at an expenditure of approximately $200,000.00. Two separate tube stills are to be erected, one to be used as a topping still and the other as a re-run still. Each unit will use the vacuum method of distillation and have a rated daily capacity of 2000 barrels. New equipment to be erected also includes a 98-ft. fractionating tower.

Test runs have been made of the new cracking equipment recently completed at the Marathon Oil Company's Fort Worth, Tex., and Bristow, Okla., plants. The two units were constructed by M. W. Kellogg Company, each having a capacity of 1500 bbl. daily and operating with gas oil as cracking stock.

●

Construction work has been commenced by J. H. Edwards, H. H. Coffield, George P. Mann and associates on a 2500-bbl. daily capacity crude refinery at Overton, Tex., on the west edge of the East Texas field. The plant will be operated under the name of Rusk Gasoline Company, with a capital stock of $50,000. Rusk Refining Company, owned by the group, was recently sold to Oil Refineries, Inc.

●

Natural Gasoline

The Skelgas Company is building a large plant for the distribution of liquefied petroleum gases at Minneapolis, Minn. The Sun Oil Company will manufacture liquefied petroleum gas at Marcus Hook, Pa., Toledo, Ohio, and Yale, Oklahoma.

●

During the past two months the Southern Pacific Railroad has been using butane as fuel for driving specially built locomotives equipped with internal combustion engines. The experimental train, operated regularly between two California terminals, consists of a coach, baggage car and Pullman. The summary of cost data is said to indicate economies of from two to three cents per mile for fuel and one to two cents per mile for lubricants. The trend in the railway industry at present is toward speeding up passenger rates of travel and if additional experiments prove satisfactory, the use of internal combustion engines may become general. In that case light fuels made from petroleum will find a greatly increased market.

●

The Magnolia Petroleum Company is erecting a 25,000-gal. daily capacity well pressure absorption gasoline plant near Kings Mill, western Gray county, Texas Panhandle district. Gas will be supplied by near-by producers.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending May 27, 1933

I.P.I. Figures

(Figures in Barrels of 42 Gallons Each)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbls.	Gas and Fuel Oil Stocks
East Coast	99.1	496,000	77.7	6,670	344,400
Appalachian	95.0	82,000	60.7	800	59,100
Ind., Ill., Ky.	97.5	279,000	65.8	3,856	341,400
Okla., Kans., Mo.	84.9	220,000	56.4	3,151	257,400
Inland Texas	56.4	98,000	55.1	2,213	117,300
Texas Gulf	97.7	458,000	84.5	6,178	506,500
Louisiana Gulf	97.3	113,000	79.6	2,057	74,400
No. Louisiana-Ark.	88.5	43,000	54.4	567	29,500
Rocky Mountain	90.8	36,000	26.1	673	71,400
California	94.6	463,000	53.5	99,092	197,700
Total May 27	91.6	2,288,000	64.8	125,257	1,999,100
Total May 22	91.6	2,266,000	64.1	124,009	1,999,100

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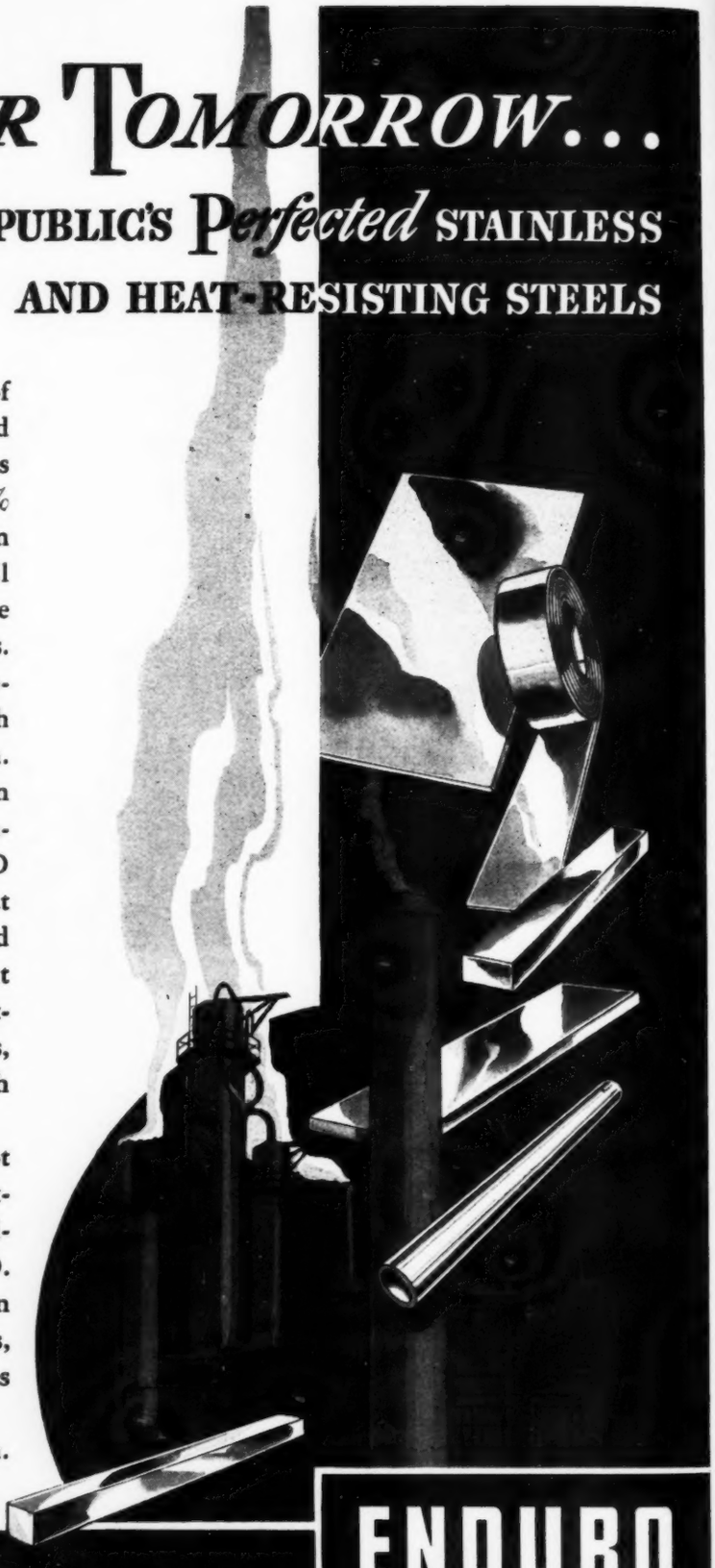

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An Overall Comparison of Various Methods of Refinery Fractionation . . . .

By T. B. LEECH
Refinery Engineer

IT has been demonstrated that for any given temperature single flash vaporization of petroleum is more economical than multiple flash vaporization in heat requirements, that the quantity of available vapor is larger, the quantity of residuum is smaller and the overlap between the two is less, using the former rather than the latter method.

It has also been demonstrated largely in the field of light hydrocarbons that if extremely good fractionation is required not over two streams, namely, top and bottom, should be taken from any one fractionating tower. During the past few years some refiners making more or less short cuts such as may be required in the production of high octane gasoline, naphtha for reforming, various solvents, certain grades of kerosene and special Diesel fuels, have leaned to this type of fractionation and several units embodying the principle have been installed.

It is the purpose of this article not only to discuss fractionation but also vaporization in light of the facts set forth in the foregoing paragraphs. This discussion will be from the economic standpoint, economy being the watchword of the refiner today.

Four existing types of fractionation have been considered. While the units were of different sizes for purposes of comparison they were all placed upon the same basis with reference to throughput, quantity of crude and cuts produced. It was assumed that each unit charging crude oil would produce a light gasoline, solvent (or reforming naphtha), kerosene, gas oil, and a fuel oil stripped in each case to the same degree; that a measure of the satisfaction of each unit would be the flexibility, so that the percentage and quality of each cut could be varied over a wide range. As this problem has to do particularly with refiners it was assumed, to permit comparison, that it would never be necessary in present refinery practice to make cuts of individual hydrocarbons or, in fact, cuts of less than 125-deg. boiling range. As discussion of any other than pipe still distillation is considered obsolete this article confines itself to fractionation as limited by pipe still heating.

Methods of operation are first outlined and later discussed from an efficiency and economic viewpoint. Referring to drawing No. 1, it will be seen that heated crude, temperature depending upon specific conditions, enters the first tower above a stripper and below a fractionating section. Light gasoline is taken from the top of the tower limited as to end-point by reflux conditions and temperature of the feed while the topped crude is withdrawn from the tower bottom. Crude is heated between each tower, in different coils in the same pipe still or in separate pipe stills for flashing in the next tower.

Reflux is supplied to the top of each fractionator by a reflux condenser or, as in the case illustrated, is pumped back. This method of distillation gives maximum flexibility, so that almost any cut limited by the content of the crude oil and by proper design can be produced at the will of the operator.

This system is, however, expensive to install and operate as will be demonstrated later.

In Method No. 2, drawing No. 2, crude hot enough to single-flash off all desired products is admitted to the primary tower, the vapor being conducted through the successive towers. Topped crude is taken from the bottom of No. 1 tower, successively lighter cuts from the bottom of each subsequent tower and the lightest gasoline from the top of the final tower.

A reboiler must be provided for each tower to procure the desired initial on the bottom cut or large quantities of steam must be used for stripping in order to obtain the desired initial on the various products.

The bottom products from the reboiler are pumped to storage, the same pump serving to reflux the preceding tower. The final tower can be served by a reflux condenser or condensate can be pumped back. This method of operation is more desirable than the previous one, but installation and operating costs are higher than results justify.

The type of unit illustrated by drawing No. 3 shows a single flash system in which crude is flashed at a temperature sufficient to give the desired total amount of distillate and the desired bottoms. In this method of fractionation the stripped fuel is taken from the bottom of the tower, the light gasoline from the top, and side cuts satisfactory as to end-point are taken from the main tower into their respective strippers, stripped to required initial with steam and cooled. Top reflux can be either from reflux condenser or pumped back; reflux for each side cut is discharged into the tower after being stripped and cooled. Use of either hot reflux or equilibrium reflux further complicates the system. This method of fractionation has advantages over that illustrated in drawing No. 1 and drawing No. 2, but also has certain disadvantages.

The unit depicted in drawing No. 4 is also a single flash fractionator in which, similar to unit No. 3, the topped crude stripped of light components is withdrawn from the tower bottom and the light gasoline is the overhead product. Reflux is preferably pumped back. This unit differs radically from No. 3 unit in that the side streams controlled as to end-point are withdrawn from the main tower, brought to desired initial in the side strippers, cooled and sent to storage. The end-point of each side stream is controlled by the tray from which it is withdrawn and by the amount of reflux

passing down the tower from the point of side withdrawal. This type of fractionation is the most desirable of the four discussed when both initial cost and economy of operation are considered.

Comparative Efficiency Unit No. 1

Advantages. Unit No. 1 has the distinct advantage that it provides the greatest flexibility of any of the units illustrated; this predicated on the fact that average refinery cuts are never under 125 deg. in range. The diameter of the towers can be somewhat smaller than for other systems of fractionation. Crude oils can be heated to whatever temperature is desired for entrance into each of the stripping sections. Reflux can be pumped back to the top of each tower in equilibrium with the product being withdrawn from that tower and in whatever quantity may be necessary. As stripping sections are provided in each tower no outside stripper is required.

Disadvantages. It was shown by Leslie and Good* that single flash evaporation is much more efficient than multiple flash evaporation. By the method of Peroomov & Beiswenger** successive distillations run on crude oil and on crude from which successively 1, 2, 3 and 4 top cuts have been made, it is clearly shown that the carrying effect of light ends of crude oil permit a much greater vaporization by single flash than is possible by multiple flash without an excessively high temperature. These results were checked in actual operation demonstrating that the multiple flash used in this system is extremely inefficient in the use of heat.

In addition the crude must be passed through successive pipe stills that are expensive to construct or through pipe coils in the same still that are difficult to control. Three unnecessary hot oil pumps must be provided to feed these coils. Four reflux condensers, accumulators, pumps and sets of control instruments must be provided for the tops of the respective towers. The vapor space and the liquid space required for any individual tower must be multiplied by four. Four stripping sections in the fractionator but no smaller in diameter than the fractionating sections must be provided. Thus the total height of towers is almost double that which would be required for a single flash tower provided with proper side strippers.

Inasmuch as from a practical standpoint, no better results can be obtained by this method of operation than by other methods it should not be considered.

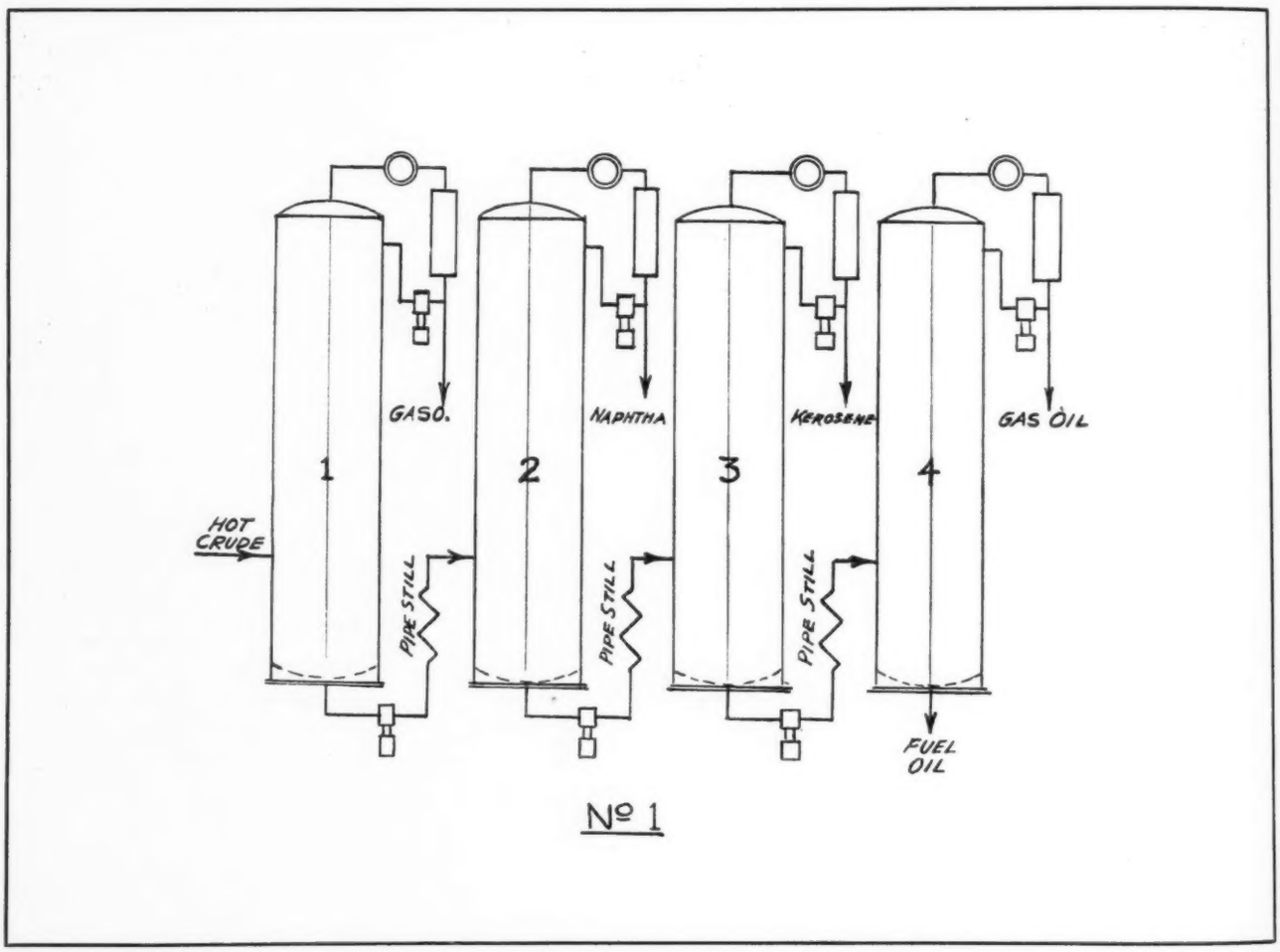
Comparative Efficiency Unit No. 2

Advantages. In the method of fractionation illustrated in drawing No. 2 advantage is taken of the fact that single flash vaporization is much superior to multiple flash vaporization in thermal efficiency. This unit also provides for not over two cuts from any given tower and to that extent is extremely flexible.

Disadvantages. For a given quantity of crude, however, the diameter of these towers must be somewhat larger than the diameter of the towers illustrated in Fig. 1. This may not immediately appear true but the accuracy of the observation will be realized when it is noted that reflux provided in No. 4 tower actually provides reflux from a heat standpoint for all the previous towers.

As an additional disadvantage the stripped material returned to each preceding tower as reflux is heavier than the

Industrial Engineering Chemist, April, 1927, page 453.
**Proceedings A.P.I., ninth annual meeting.



Nº 1

material coming overhead and thus throws the system out of equilibrium. Therefore, when the reflux is revaporized and driven into the succeeding tower the equilibrium temperature is higher than it would have been if reflux in all cases had been in equilibrium with the product coming overhead. This necessitates slight additional stripping either by heat medium from a furnace or steam, in order to obtain the sufficiently stripped product from the bottom of the tower and make the entire system function as required. The same condition also adversely affects reflux conditions.

The same objection as in system No. 1 holds; that four vapor separatory spaces in the top of the tower must be provided, that four stripping sections, not decreased in diameter, and four liquid sections are necessary. In addition, for adequate control there is required four reboilers together with temperature controls and three hot reflux pumps that are not necessary in certain other systems.

Comparative Efficiency Unit No. 3

Advantages. Unit No. 3 also has the distinct advantage of making use of single flash vaporization. If fuel oil is very expensive in a particular refinery location, there is a much greater heat head available for heat exchangers in which crude can be utilized to cool the various side streams than is available from a reflux vapor heat exchanger or a vapor heat exchanger alone.

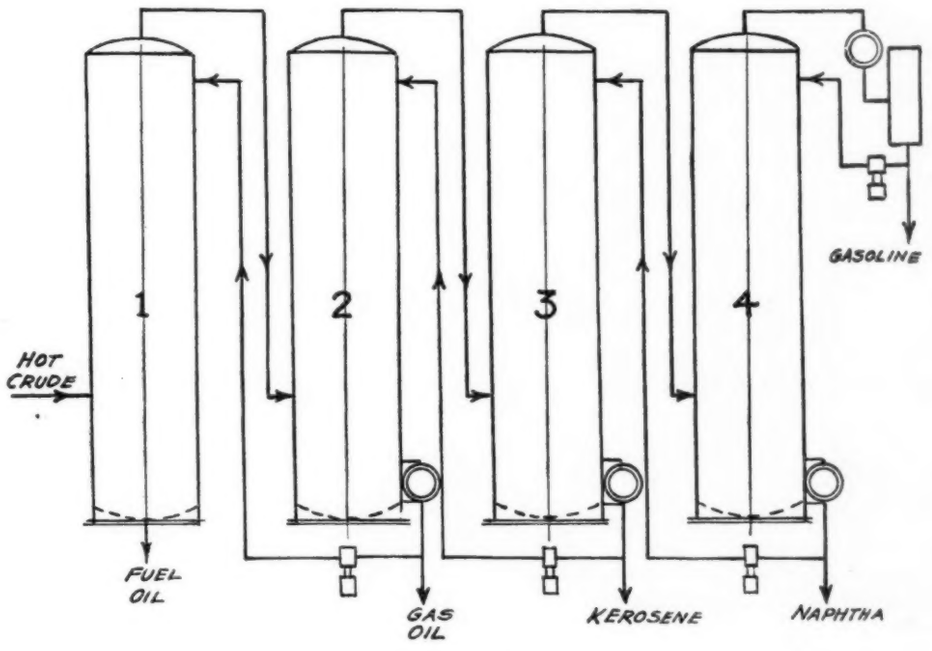
This tower can be offset above the point of vapor inlet from each side stripper; having its diameter decreased approximately one foot above each cut on the basis of a tower with a 10-ft. lower section diameter. The possible decrease, of course, depends upon the mass velocity in the next section above. Control of an individual side cut independently of the operation of the remainder of the tower is, within certain limits, possible.

Disadvantages. The disadvantages of the system illustrated are, however, manifold. Introduction of reflux at the point of withdrawal for each side stream demands that four reflux accumulators, reflux pumps and instruments be provided instead of the one that would be necessary if the tower were top controlled. The saving in offsetting the tower is largely nullified by the structural arrangement necessary where a tower offset is made. Individual control of side streams is of doubtful advantage, as it may possibly upset the tower equilibrium to an extent that it cannot be made to function.

When a single main tower is used for fractionating various side and top cuts to end-point it sometimes becomes necessary to raise or lower the side stream withdrawal points on the main fractionating column. This is especially true if rather close cuts are to be made and if the equilibrium of the tower is to be disturbed as little as possible. Usually enough nozzles are provided so that side withdrawals can be made over a range of six bubble pans. Assuming that the same flexibility is desired for the type of main fractionating column illustrated, the break in size of tower would usually be such that only a range of three pans would be available.

To each section of the main fractionating tower, therefore, would have to be added three additional pans in order to permit maximum flexibility, and these additional nine pans in a large diameter tower are certainly a deterrent to this type of installation.

Introduction of reflux into the main fractionating tower just above the point of withdrawal of each individual cut



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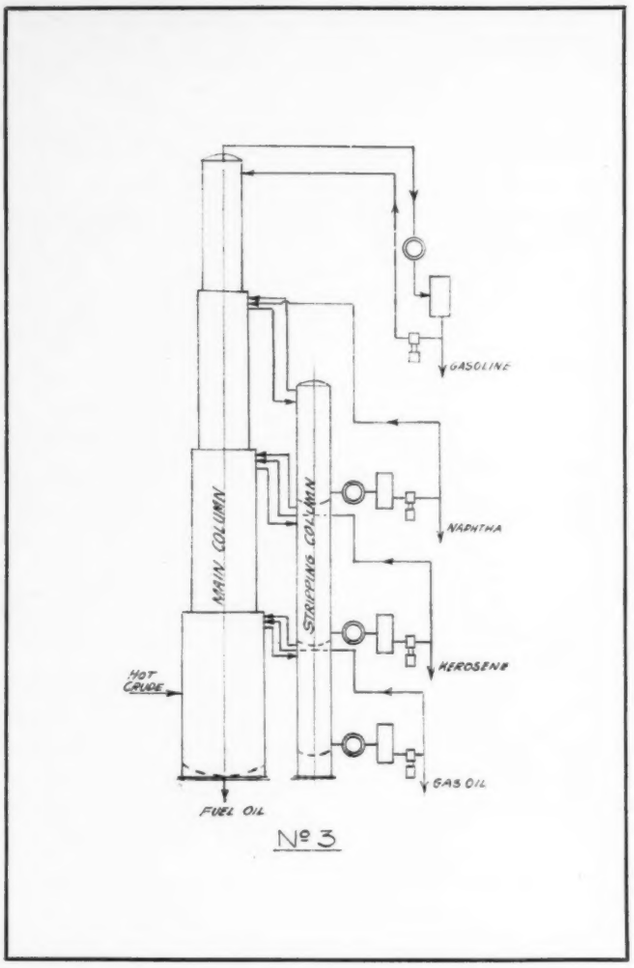


implies that the total amount of reflux will be returned to the side stripper after having absorbed a greater amount of light material than would be present in the side drawn product only. The larger quantity necessitates either a higher temperature for reboiling of the side cut streams or a greater quantity of steam to bring the side cut into equilibrium condition to obtain the desired initial. This larger quantity of material to be stripped further necessitates a larger than minimum size for each of the stripping sections and, consequently, increased cost.

It, therefore, would appear that this system is only desirable where the high cost of fuel would make the possibility of heat exchange more attractive than the cost and difficulty of four-point control and operation.

Comparative Efficiency Unit No. 4

Advantages. Unit No. 4 has the distinct advantage of utilizing the benefits to be obtained from single flash vaporization. Close cuts can be withdrawn from any plate that will produce the proper end-point cut with a minimum disturbance of equilibrium conditions within the tower. Inasmuch as no extraneous material not in equilibrium with the vapor or liquid in a particular portion of the tower is reintroduced into the main column, there is a minimum of disturbance of the conditions within the column.

Only a single condenser or cooler, single reflux accumulator, reflux pump and set of control instruments are required. Control valves for side drawn streams, once a particular pan is selected for a single cut, need no attention. Therefore, the system is much easier to control than any of the aforementioned systems. As only a fraction of the material is withdrawn to the side stripper as compared with the material in Method No. 3 the side stripper can be smaller in diameter and, as the material withdrawn is at its own equilibrium condition as to temperature and pressure, the introduction of a relatively small amount of extraneous heat or steam is sufficient to reduce the initial of any side drawn material to that required for the side drawn product.

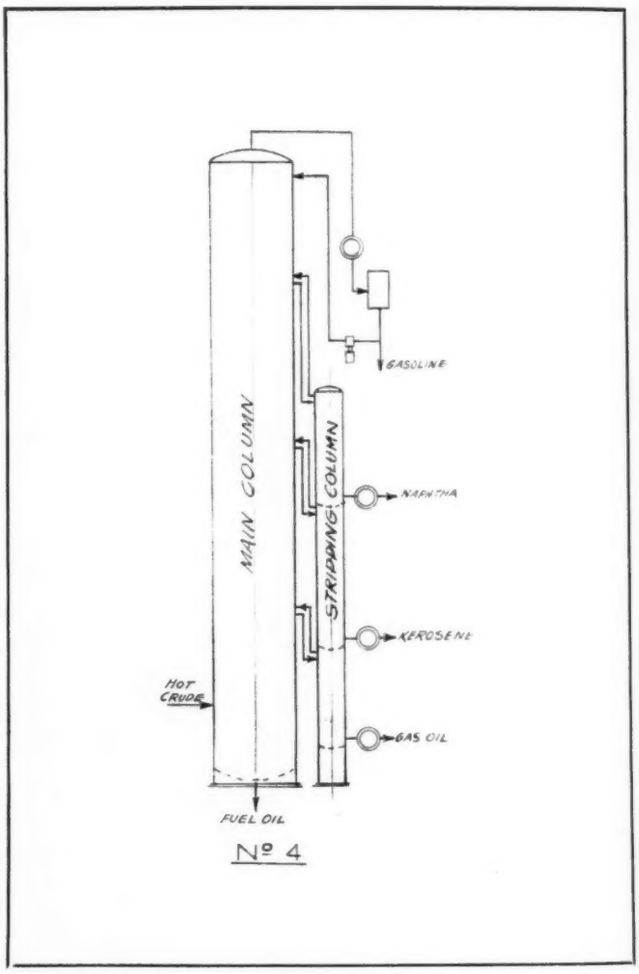
If reflux conditions are such that the relatively low heat head of the overhead material can not be used to greatest effect in heat exchange with crude oil, the high heat head of each of the side drawn streams may be effectively used by the installation of proper liquid-to-liquid heat exchangers.

Disadvantages. The disadvantage of this particular system lies only in the fact that reflux is not introduced for each of the side drawn streams and that, consequently, only the amount of the side drawn product is available at a higher heat head than the overhead material for use in exchangers.

Conclusion

Taking into consideration all the various advantages and disadvantages, not only of initial expense, but of maintenance cost, and operation of the accessories attached to the various systems outlined, it would appear that in general the fractionating system shown in drawing No. 4 is greatly superior to any of the other methods. Exceptions to this would only be valid when unusual local conditions existed. These would then, indeed, have to be extremely unusual to justify the use of any of the other processes discussed.

This discussion has been predicated on the fact that the average refiner does not wish to produce cuts of less than approximately 125-deg. range. For those refiners who wish to produce cuts of smaller boiling range a method will be outlined in a subsequent article.



Economy in Auxiliary Stand-By Unit

By F. B. TAYLOR, JR.
Panhandle Eastern Pipe Line Co.

STANDARD equipment installed in auxiliaries at pumping stations has, in a number of late instances, been supplemented by a small stand-by unit of the ordinary gasoline-motor type. Adapted to the use of natural gas as a fuel, this unit gives a three-fold service to increase the margin of safety against shut-downs during capacity operation: First, in economically meeting the lighter auxiliary power demands of the summer months; second, in providing power while other auxiliary equipment is being dismantled for repairs and adjustments and, third, it constitutes a reliable emergency unit, using either natural gas or gasoline as a fuel and one that does not require compressed air for starting.

The selection of a suitable motor for a permanent installation of this order depends upon the power to be demanded of the unit, the availability of fuel, and the generating equipment on hand or obtainable. The first requirement will be determined by reducing the continuous current load (lighting, etc.) to a horsepower basis, to which is added the extra demands of air compression and the pumping of water, making an additional allowance for line losses. Greatest economy is obtained from a natural gas fuel, cut to a low basis and fed through a manifold. If generating equipment on hand will satisfy the needs of the proposed unit, the gasoline motor end must deliver its maximum power at an r.p.m. corresponding with the rated speed of the generating unit. However, if the equipment is to be requisitioned, the r.p.m. of motor and generator may be predetermined.

Type of unit most adaptable will depend on local conditions

In transforming a motor of the tractor, truck, or automobile type to auxiliary use, the radiator, fan assembly, clutch, oil pressure gauge, gasoline line and electrical circuits (with the exception of ignition) are entirely removed. If it is planned to use a closed cooling system the water pump must remain, although the impeller is immaterial if the water flow is from a tower.

After mounting the power assembly on suitable foundations the fuel line is connected between the air filter and the carburetor, no mixer being required. Such assemblies vary greatly in ease of starting with raw gas and it is advisable to install a small gasoline reserve tank and valve-controlled gravity line to the carburetor. Sufficient natural gas may be fed through the gasoline mixture after the unit has started to continue its operation after the gasoline supply has been shut off. For this purpose a valve in the natural gas supply is necessary.

For a 6-cylinder unit a 1-in. pipe will carry enough cooling water to the engine. The discharge (from the top radiator connection) and drain lines should exceed the diameter of the water intake by ¼ in. to ½ inch. Control of engine temperature is obtained by regulating the flow of jacket cooling water.

A starting motor should be used. For this purpose a heavy duty 6-volt battery of not less than 17 plates is required, unless two batteries of ordinary size are connected in parallel. The starting switch can be conveniently located, the negative battery cable being grounded to the frame. Either battery or magneto will supply the ignition.

The oil pressure gauge, removed before the installation, is reconnected to the oil pressure outlet by a short coupling. It is necessary that a valve be inserted in this line, and cracked only enough to indicate accurately the pressure; otherwise, the oil pump pulsations acting directly upon the gauge will cause injury to the mechanism.

Unless it is desired to operate the unit manually, a governor may readily be installed to work from the cam shaft or it may be geared from the crank. Generally speaking, particularly where the current load is variable, automatic control is desirable. The conventional fly-ball governor will be found practicable and sufficiently sensitive in operation to satisfy this need, the point of control being the natural gas-carburetor orifice.

The generating end of the installation is connected directly to the power unit flywheel or crankshaft extension. In either case a flexible coupling is advisable. If an alternator and exciter are to be installed their method of interconnection is not important. Current generated from such a setup is best controlled manually from the auxiliary control panel.

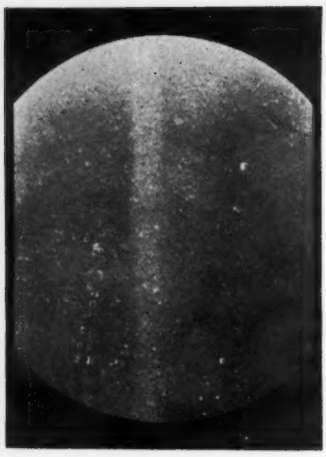
Two complete installations of this order at the Louisburg and Liberal compressor stations of the Panhandle Eastern Pipe Line Company have given highly satisfactory service for the past year and a half. During this period the average fuel gas consumption was between 16 and 18 cu. ft. per hp.-hour. This compared favorably with the usual 11 to 13 cu. ft. per hp.-hr. obtainable from the 160-hp. to 200-hp. auxiliary units in common use.

Figuring both at an 80 per cent load, for an estimated saving on a percentage basis, the transformed gasoline unit (using 50 hp. as an optional desirable power factor) if operated continuously 24 hours a day for a month, will consume 489,600 cu. ft. of natural gas fuel, effecting a saving of 816,400 cu. ft., assuming the operation of the larger unit to be continuous over the same period.

It must be remembered that these figures will vary with the B.t.u. of the fuel gas, the thoroughness of the mixture, friction losses of the particular unit considered and the fluctuation of the load requirements.

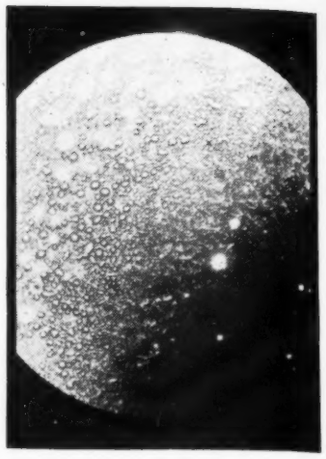
Calculating on a theoretical basis, and considering the actual hp.-load requirements to be identical on both units, the average fuel curves will show a greater efficiency for the unit of low power than for that of the higher. Provided that the smaller unit is operated at rated capacity, or 50 hp., the fuel efficiency will be 100 per cent. Inversely, the larger unit, delivering the same horsepower, will be operating at only 26 per cent of capacity load, resulting in a relative fuel efficiency of only 41.5 per cent. From this and using 1000 B.t.u. fuel, the net saving is 714 cu. ft. per hr., or 514,000 cu. ft. per month. Oil consumption is correspondingly reduced and replacements are commensurate with the initial installation costs.

Properly set up, a unit of this type is a practicable, economical addition to any pumping or compressor station.



LEFT—1. Emulsion (fresh)

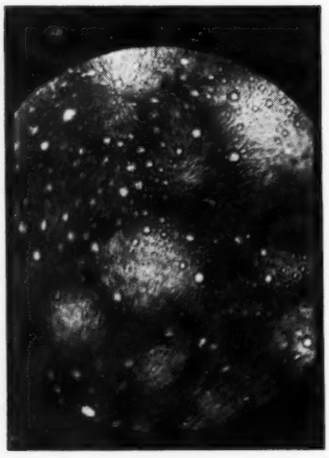
RIGHT—2. Breaking effect (with cresol)



Manufacture of Asphalt

THE object of this work was to study the characteristics of acid sludge from mixed base residual products and to determine the possibilities of preparing asphalts of good quality from the sludge. The work of Wier, Houghton and Mazewski[1] has demonstrated that acid sludge may contain but negligible quantities of reaction products. This fact has been substantiated by work done in this laboratory.

Working with acid sludge prepared from residual oils from Oklahoma City crude, it was possible to recover approximately 94 to 97 per cent of the sulfuric acid used, and to prepare asphalts of varying hardness, good ductility, and composed almost wholly of bitumen. The work was done in the laboratory on a small scale and the sludge was separated and treated before it had time to harden.



3. Breaking effect (with cresol)

The method used was to flux the freshly prepared sludge with a small amount of gas oil and then to agitate it with water, thus forming an emulsion. This emulsion was then broken by means of heat or by the use of a breaking agent. The pitch-like product remaining after breaking the emulsion was distilled to produce asphalts of varying consistencies.

The breaking agents found to be the most effective were phenol and cresol, the latter being more effective than the former. Certain organic solvents such as alcohols and ketones were found to act as breakers, but were comparatively inefficient.

It is realized that there are several difficulties confronting the refiner in attempting to apply the above method of recovery of asphalt from acid sludge. One is the hardening of the sludge that often occurs right in the agitators. Another obstacle is the patent situation, which is quite complicated. However, it is thought that this report may supply refiners with useful information.

The product used in the experiments was residual oil from Oklahoma City crude petroleum. The oil was agitated mechanically for about 20 minutes in a beaker with the acid. It was found advisable to add the acid in fractional amounts rather than adding it all at once. The treating temperature was maintained between 125 and 132 deg. fahrenheit. After settling and separating the sludge, it was fluxed with from one to five per cent of light gas oil, depending upon the character of the sludge. By rapid agitation with water the sludge was then emulsified. This emulsion was brown in color and was very finely divided. A study of the emulsion revealed that the disperse phase consisted of dilute acid, while the continuous phase was made up of oil material. The protective colloid apparently was a resinous, asphaltic material. This emulsion was then broken by means of heat, breaking agents, or a combination of the two. The tarry matter was next separated and treated with a small amount of lime in order to neutralize any free acid remaining in that portion. The calcium sulfate that formed was separated out and the tar was subjected to a vacuum distillation. By doing so, an asphalt of any desired consistency could be made.

Temperatures as high as 700 deg. fahr. were used in the distillations without causing appreciable decomposition, as was shown by the absence of coke in the product. The following is representative of tests on the products.

Sp. Gr. @ 60 deg. fahr.	1.09
Penetration @ 77 deg. fahr.	90
Softening point	152°F.
Flash	435°F.
% sol. in CS_2	96%
% sol. in 88 naphtha	82%
Free asphaltous acids	1.2%
Asphaltous acid anhydrides	1.4%
Asphaltic resins	21.05%
Asphaltenes	26.6%
Oily constituents	50.10%

An interesting characteristic of the products was the ductility. The products possessed ductilities well in excess of 100

[1]Ind. Eng. Chem. 22 (1930), p. 1293.

By

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and R. I. JACOBI

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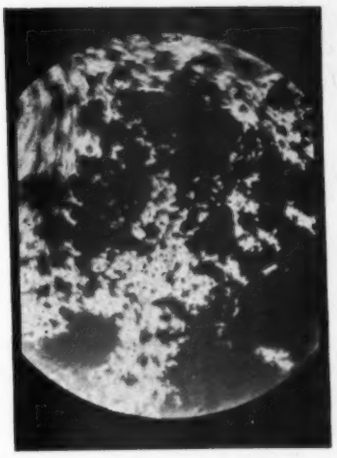
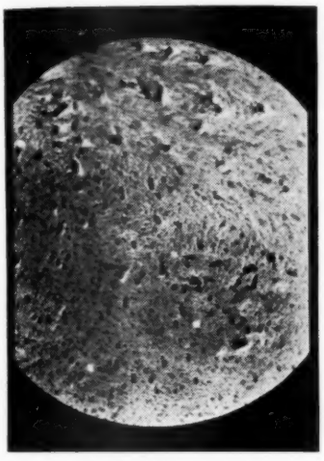


5. Coking finish

lt from Acid Sludge



4. Coking start

centimeters and could be drawn out into long strings at ordinary temperatures. This characteristic is probably due to the high percentage of asphaltic resins. These resins also probably tend to make the asphalt stable.

The products were subjected to accelerated weathering tests. The shape of the curves of exposure time against penetration from the products made from acid sludge were about the same as for the commercial asphalts used for comparison. The conclusion was drawn that the asphalts from acid sludge are at least fairly resistant to weathering.

The work done so far on this problem indicates that the action of the acid on uncracked residual products is one of solution and precipitation. The formation of reaction products is negligible. In commercial practice, the quantity of reaction products probably is considerably greater than in these experiments, but still much less than might be supposed.

Asphaltic matter in petroleum generally is considered as being in colloidal solution in the oil, but all authorities do not agree as to the chemical nature of the disperse phase. The belief that is most generally accepted is that the dispersed phase is composed of organic oxygen, sulfur compounds, or hydrocarbons of high molecular weight. The protective colloid may be oils of high molecular weight or readily absorbable resins. Another view is that the dispersed phase simply is colloidal carbon, but this belief is not generally accepted.

Whether the disperse phase is composed of organic oxygen and sulfur compounds and hydrocarbons, or colloidal carbon, is of interest here. It is reasonable to expect that organic oxygen and sulfur compounds might be slightly soluble in the sulfuric acid but the colloidal carbon would not be soluble. However, any dispersed substance might be precipitated by the sulfuric acid, because acids generally are effective precipitating agents for dispersed substances. On the other hand, since dilute acid is not effective in precipitating asphaltic matter from petroleum, the reasonable conclusion is that the solvent effect of the acid is more important than the precipitating effect.

The hardening or coking of sludge is an interesting phenomenon meriting serious study. Our work indicates that this coke-like substance generally is not carbon but is one of two things: (1) Change from emulsion type of colloid to a gel type of dispersion, or (2) The sulfuric acid causes additional polymerization or condensation of the organic sulfur and oxygen compounds to compounds of very high molecular weight, possibly resembling carbon or coke. It is hoped to carry on this investigation until a definite conclusion is reached.

Light petroleum naphtha precipitates asphaltic matter, or to be more precise, asphaltenes, from oil. The asphaltenes thus obtained are somewhat different from the asphaltic matter recovered from acid sludge by emulsifying and breaking the emulsion. The reason for this can be explained satisfactorily by saying that the naphtha dissolves the protective colloids, thus eliminating them more completely than in sulfuric acid treatment. The asphaltenes obtained by the precipitation with light petroleum naphtha are not readily dispersed again in petroleum oil, but if first taken up by a solvent, such as benzol or carbon tetrachloride, then dissolved in the petroleum oil and the oil heated to drive off the solvent, the asphaltenes become fairly well dispersed in the oil again. However, they are not so well dispersed as they were originally, since they will settle out over a period of time. It is interesting to note in this connection that the asphalt from sludge is more readily soluble in petroleum oil than asphaltenes, but often not so well as desired for commercial purposes.

Several micrographs showing the fresh emulsion, the breaking effect with cresol, and the coking at start and finish, are reproduced in the illustrations accompanying this article. A select bibliography of articles on the manufacture of asphalts from acid sludge is also appended, together with a partial list of patents on the preparation of asphalt from acid sludge.

BIBLIOGRAPHY

The Constitution of Asphalt, Dr. F. J. Nellensteyn—Journal of the Institute of Petroleum Technologists, Vol. 10, 1924, 311.

The author lists the following general characteristic properties of asphalts: (1) Color; (2) Behavior on congealing; (3) Behavior on distillation, and (4) Solubility.

Asphalt is a mixture that contains both asphaltic material and other extraneous materials. The asphaltic materials that constitute the essential part of asphalt are the asphaltenes.

Asphalt is formed by the distillation of almost all the higher hydrocarbons, and by the decomposition or dissolution of the C-H bond. By discussing the pyrogenic decomposition of the simpler hydrocarbons, the author gives the basis for the decomposition of the C-H bond and shows how this reaction is related to the formation of asphalt.

The oxidation of the paraffin is discussed, bringing about the following conclusions:

1. Oxidation with elementary oxygen transforms the higher paraffin hydrocarbons into a mixture of fatty acids with about one-half the average number of carbon atoms in the molecule.
2. The reaction takes place over a large temperature range.
3. The reaction takes place without a catalyst.
4. Oxidation with air or with a gas mixture of low oxygen content gives the same results as with pure oxygen.

These reactions also indicate a dissociated condition of the hydrocarbon molecules, the dissociation products being oxidized by the oxygen to fatty acids.

When paraffins are oxidized, oxygen is found in the residue, distillate and gaseous products. This is not the case when an asphalt-base oil is oxidized. Oxygen has been found in the residues, distillates and gaseous products of mixed base oils but this is due to the presence of paraffin. By the oxidation of asphalt-base oils, asphalt is formed that contains colloidal carbon.

Both Tyndall effect and Brownian movement have been observed on solutions of the asphaltenes. This may be due to the presence of either colloidal carbon or to large molecules.

Asphalt was synthesized by making electrical dispersions of carbon in various media.

* * * *

The Relation of the Micelle to the Medium in Asphalt, Dr. F. J. Nellensteyn—Journal of the Institute of Petroleum Technologists, Vol. 14, 1928, 134.

The three principal components of asphalt are as follows: (1) The Medium; (2) The Lyophile part—protective bodies, and (3) The Lyophobe part—elementary carbon.

The author presents an explanation of the flocculation of the disperse phase of asphalt by low boiling benzine. Any liquid that will tend to increase the micelle-medium interfacial tension will tend to cause flocculation. The relative merits of ether, benzene, N-hexane, ethyl acetate, acetone, and butanone are tabulated with respect to variation in surface tension.

A short discussion of the action of peptizing agents, such as chloroform, benzol, carbondisulfide, and pyridine, is also given.

This and the following page contain abstracts from some articles that deal with the composition of asphalt. A list and short description of the United States patents covering the preparation of asphalt from acid sludge is also included.

The Constitution of Asphalt, H. I. Waterman and Dr. F. J. Nellensteyn—Journal of the Institute of Petroleum Technologists, Vol. 11, 1925, 81.

"Carbon was isolated by long continued extraction of a blown asphalt-base oil. The solvents used were: gasoline (40 deg. to 60 deg.); gasoline (60 deg. to 80 deg.); a mixture of gasoline (60 deg. to 80 deg.) and carbontetrachloride, carbontetrachloride and benzene. These were used in the order named to carry out this extraction. The workers conclude that colloidal carbon is an essential constituent of asphalts since similar results were obtained on other types of asphalt and on coal tars.

* * * *

The Chemical Composition of Asphalts and Asphaltic Materials, V. Kalichevsky and S. C. Fulton—National Petroleum News, Dec. 23, 1931, 33.

A description of analytical methods for asphalts based upon Marcusson's five groups is presented. These five groups of compounds making up asphaltic materials are:

1. Asphaltic Acids—Extracted in the form of salts from a benzol solution of the asphalt.
2. Asphaltic Anhydrides—Saponified by treatment with alcoholic alkali solutions.
3. Asphaltenes—Precipitated by the addition of low boiling petroleum ether to a benzol solution of asphalt after the removal of the acids and anhydrides.
4. Asphaltic Resins—Extracted by Florida clay from a petroleum ether solution after the removal of 1, 2, and 3.
5. Residual Oil—The residue not absorbed by the earth.

The properties of each of these five constituents are discussed and their function in an asphalt is given. The asphaltenes give hardness and impart brittleness and high melting point, while the asphaltic resins impart stability, ductility, and tensile strength.

The fact that blowing an asphaltic residue with air does not change the oxygen content of the residue is brought out. Neither sulfur nor oxygen are considered important constituents of asphaltenes or asphaltic resins. The tendency for asphaltenes to change to carbenes due to the action of sunlight, thus losing the property of dissolving in various solvents is pointed out. It is believed that during acid treatment, the resins are partially changed to asphaltenes and are partially dissolved by the acid.

* * * *

Some Observations on the Colloidal Character of Asphalts, Kirk and Reyerson—Journal of Physical Chemistry, Vol. 29, 1925, 865.

Asphalts in general are sparingly soluble in acetone and are very soluble in carbon disulfide. Carbontetrachloride occupies an intermediate position. An oil asphalt was selected that was low in inorganic matter. A portion of the asphalt was shaken with each of the above liquids and allowed to stand for several days. The asphalt disappeared completely in the carbon disulfide and no collodial particles could be detected under the ultramicroscope. Only a small portion of the

asphalt dissolved in the acetone. An extremely few particles were visible in the field of the ultramicroscope. The asphalt disappeared completely in the carbontetrachloride. No particles were visible. The field was light blue in color, evidently due to particles of slightly larger than molecular size. On standing for several months, the carbontetrachloride solution showed particles due to the agglomeration of the small particles mentioned above. The acetone solution showed an increase in both size and number of particles.

From these facts, the indications are that the dispersion of asphalts in organic liquids involves both the dispersion of organic matter and the possible dispersion of inorganic matter. The choice of solvent is a very important matter.

* * * *

Colloidal Chemistry of Asphalts, Charles Mack—Journal of Physical Chemistry, December, 1932, 2901.

The three main constituents of asphalt are asphaltenes, asphaltic resins, and oily material. Asphalt forms a lyophilic sol. Asphaltenes are the disperse phase, while the resins and oily matter make up the continous phase.

Lyophilic sols are characterized by relative stability, the difficulty in detecting the dispersed particles under the ultramicroscope, high viscosity and elasticity, gel-forming properties, and the low solubility of the solute in the solvent at the temperature of gel formation.

The viscosity of asphalts is discussed in detail. Viscosity measurements show that asphalts have high relative viscosity at low temperatures but they behave as ideal solutions when in the liquid state.

By the application of an equation relating viscosity to the molecular weight of the solute, together with some adsorption measurements, the author points out that contrary to general opinion, high relative viscosity is brought about by association rather than by the solvation of the dispersed particles. A "concentration function," which relates viscosity and the size of the dispersed particles, has also been derived.

* * * *

Acid Treatment of Lubricating Distillates, Weir, Houghton and Majewski—Industry and Engineering Chemistry, December, 1930, 1293.

These workers point out that in relation to the reaction taking place when an oil is acid treated, few reaction products may be expected. Flocculation of the dissolved bitumens takes place, followed by their absorption by the acid to form a solution or an emulsion. That these bitumens can be returned to the oil has been shown. By replacing these bitumens in the oil, no appreciable change in the oil is noticed as a consequence of the action of the acid.

Interesting data on color removal by the use of acid varying in concentration from 75 to 98 per cent are given. Conditions for optimum color, yield, stability, gravity, etc., are also brought out.

PATENTS

Patents covering the preparation of asphaltic materials from acid sludge, have been granted to many workers. The greater majority of these are based upon a steam or hot water cooking process whereby the acid layers and asphaltic layers are separated.

In 1859, Henry Pemberton was granted a patent for the treatment of acid sludge (Patent No. 24,952). Under this patent there are four major steps in the sludge treatment.

1. Preliminary heating to obtain a separation of free sour oil.
2. Agitation of the acid sludge residue with hot water and steam.
3. Separation of weak acid and tar.
4. Recovery of weak acid by pan evaporation.

In 1909, J. L. Gray claimed the production of pitch and asphalt from petroleum sludge by digestion with water, steam or dilute acid recovered from the sludge, until a major part of the acid had been recovered. The tar, comparatively free from acid, was heated with a steam spray until the mass was converted into pitch.

In 1910, Schildhaus and Condra obtained a patent covering the heating of acid sludge to about 250 deg. cent., and at the same time introducing air into the retort. The liquid hydrocarbons distilled off and condensed. The sulfur dioxide gas produced is then washed with a heavy oil and then with sulfuric acid.

U. S. Patent No. 1,211,721, granted to Landsberg in 1917, covers the washing of the sludge with sulfuric acid, gasoline and water. The resulting product can be used as a road binder.

Bennett, Murphy and Story, under the terms of U. S. Patent No. 1,568,261, treated the sludge with alcohol and benzine or a similar coal tar derivative. After distilling the solution, which was previously filtered, a product remained that was asphaltic in character and was used in paints.

In 1918, U. S. Patent No. 1,271,387 was granted to Rene de M. Taveau. Under the terms of this patent, Taveau used a method for separation of asphaltic matter from sludge that is similar to the method described in this paper. An emulsion of sludge and water was prepared under the influence of an agent. The breaking of the emulsion was brought about by heating methods. Mention is made of the use of alcohol, ether, or benzol as breaking agents.

A Partial List of Patents Covering the Preparation of an Asphaltic Material from Acid Sludge Is Given Below

Patent No.	*Date*	*Granted to*
1,869,231	1932	Piotrowski and Winkler
1,862,060	1932	Moser and Greutert
138,629	1873	Richard Gaggin
138,237	1873	Alonzo Farrar
129,041	1872	Alonzo Farrar
1,677,731	1928	Carl Sautermeister
1,642,000	1927	Louis Burgess
1,872,463	1932	Irvin H. Jones
1,855,878	1932	Earl B. Conklin
1,409,590	1932	Frederick Salathe
1,418,781	1922	Sterling H. Diggs
1,236,031	1917	Wright and Oakleaf
1,211,721	1917	Ludwig Landsberg
1,092,386	1914	Pau and Eberhart
488,628	1892	Hans A. Frasch
611,620	1898	Forward and Davidson
366,977	1929	Joseph Lawton
1,487,240	1924	Higgins and Smith
178,061	1876	Walter P. Jenney
425,905	1890	Charles Rave
190,762	1877	Walter P. Jenney
37,918	1863	Adolph Millochan
100,876	1870	Alonzo Farrar

Butt Joints Without Chill Bands Featured Phillips Line Welding

By H. C. PRICE, Welding Contractor

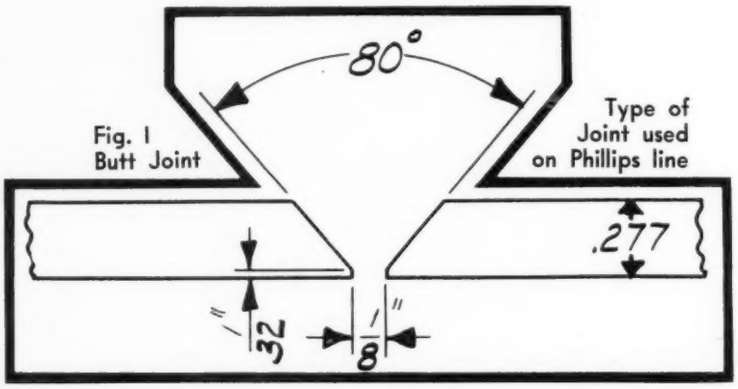


Fig. 1
Butt Joint

Type of
Joint used
on Phillips line

COMPLETION of the largest pipe line project of the first half of 1933 was celebrated recently by the first movement of oil through the Phillips Petroleum Company's 8-in. line from Oklahoma City to Thrall, Kan. Daily capacity of the line is approximately 20,000 bbl., with station sites at Oklahoma City, Fallis, Yale, Burbank, Okla., and Grand Summit, Kan. With the looping of the old 6-in. line from Thrall to their Kansas City refinery, the Phillips program involved the laying of a total of 290 miles of line.

The 210-mile line was constructed with unusual speed by the Kelly-Dempsey Company, Tulsa, Okla., general contractors, and the H. C. Price Company, Bartlesville, Okla., welding contractors. All welding was completed in 76 working days. During the first 18 days construction was completed and the line buried from Oklahoma City to a point near Yale, a distance of more than 60 miles.

A feature of this line that has attracted considerable interest was the use of butt joints without chill bands. This is the first time such a joint has been used with the electric arc on a major project and it promises to provide new economies. Heretofore it has been considered necessary to have a chill band for electric welding so that the first bead would not burn through the pipe and cause icicles on the inside. Experience on the Phillips line shows this is not necessarily true.

Unusual Joints Used

Plain end Republic line pipe .277 in. thick, containing .12 to .18 per cent carbon, was used. At first the pipe was beveled 25 deg. with a $\frac{1}{16}$-in. shoulder and $\frac{1}{8}$-in. spacing. This was later changed to a 40-deg. bevel with $\frac{1}{32}$-in. spacing. (See Fig. 1.) The first bead leaves a slightly convex ridge inside the pipe. Wherever a chill band is used on oil lines it is necessary to double bell the pipe so that there will be a smooth surface inside to prevent friction. This, of course, entails additional expense. By eliminating the chill band and the double belling, greater welding economies can be obtained.

Pipe was furnished in 45-ft. lengths, with five lengths forming a section. A line-up clamp was used. The joint was tack welded in four places and another welder followed immediately behind the tacker to put on the first head. The firing line crew then put on the second and third beads.

Welding Procedure

For the first 100 miles three gangs were utilized; for the remainder of the distance, only two. Each gang consisted of eight welders —one tacking, one putting on the first bead, three on the firing line, one tacking for the tie-in and two making the tie-in welds. The tacker and the first bead man had one helper each. The firing line men had two helpers—one man scaling and one turning the pipe. The tie-in men had one helper scaling.

Using this very efficient set-up, rapid progress was made despite the rough country through which the line runs. A great deal of rocky terrain was covered and the welding crew was almost constantly working in heavy winds. The records show, however, the following speeds for the entire project:

	Roll Welds	Bell Hole Welds
Average speed per man per day	56	20
Record speed per man per day	86	42
Actual welding time one joint	5 min.	10 min.

All welding was done by the shielded arc process, using Fleetweld electrodes and gasoline-driven welders manufactured by The Lincoln Electric Company, Cleveland, Ohio.

On the roll welds, the first bead was laid with $\frac{1}{4}$-in. electrodes, using 300 amperes; and the second and third with $\frac{5}{16}$-in. electrodes and 400 amperes of current. All bell hole welding was done with $\frac{3}{16}$-in. electrodes at 200 amperes.

Testing

A portable testing machine was employed in the field for the testing of coupons. These consistently broke in the pipe.

For the first 100 miles of the line, each section of five joints was tested with 100-lb. air pressure. Only a very few pinholes were discovered so that it was decided to discontinue the air testing in sections. Upon completion of the line at 60 and 100 miles from the start, it was tested with oil at 1200 lb. pressure and no leaks or breaks discovered.

In addition to the main line from Oklahoma City to Thrall, a 32-mile loop was also arc welded by the H. C. Price Company from Homewood to Burlington, Kan. Twenty miles of this was laid with the same type of 8-in. pipe as laid on the main line. Twelve miles of the line was laid with 8-in. used pipe, prepared for welding by cutting the ends with an automatic machine torch.

Modern Pipestill Heater Design

Article III. Recirculation Stills

By W. L. NELSON
Professor of Petroleum Refining
University of Tulsa

MANY claims have been made for the recirculation type of pipestill. In part these claims are justified, but often they lead to misconceptions. The important advantages of the recirculation still are: (1) The rate of radiant absorption can be controlled by adjusting the quantity of flue gas that is recirculated, and (2) a low rate of radiant absorption can be obtained without building an excessively large radiant section. If the heat duty of an ordinary still is increased, the rate of absorption in the radiant section increases greatly and all out of proportion to the increase in the duty. In the recirculation still the rate of absorption can be kept low by increasing the circulation of flue gas. In both types of stills the efficiency may decrease slightly but the efficiency of pipestill heaters is not of major importance to the refiner. The most real concern of the refiner is to avoid deposits of coke with resulting costly shutdowns and to avoid the discoloration of finished stocks by localized overheating. The absorption rate can be regulated in ordinary stills by using different quantities of excess air, but great losses in efficiency occur if the absorption rate is lowered by even a few thousand B.t.u.

Since the factors involved in the design of recirculation stills are numerous and far reaching in effect, two example designs are presented. The first is a simple still with no recirculation, and the second a recirculation still suitable for the same service as the first.

Example Design I—Simple Radiant Type Still

Thirty thousand lb./hr. of oil is to be heated from 300 deg. fahr. to 700 deg. fahr. vaporizing about 66 per cent. Ten million B.t.u./hr. is required for this service. A radiant absorption rate of 20,000 B.t.u./hr. per sq. ft. of projected area is allowable in the radiant section. An efficiency of 75 per cent is desirable. An oil fuel is available having a heating value (net) of 17,600 B.t.u./lb. and producing about 14.7 lb. of flue gas if burned with no excess air. Twenty-five per cent of excess air is used.

Radiant Absorption Factor—Refer to Fig. 1, Article 1 of this series[1] for rate of 20,000, R=0.535.

HEAT BALANCE

Efficiency	75 %	10,000,000 B.t.u.
Radiant Absorption	53.5%	7,140,000 B.t.u.
Convection Absorption	21.5%	2,860,000 B.t.u. (By difference)
Radiant Section Loss	3.0%	400,000 B.t.u.
Convection Section Loss	2.0%	260,000 B.t.u.
Stack Loss	20.0%	2,670,000 B.t.u.
Heat in Fuel	100.0%	13,330,000 B.t.u.

Radiant Surface = 7,140,000 / 20,000 = 357 sq. ft. projected area.

If 3-in. by 4-in. tubes are used the length of rad. tubes = 357/0.33 = 1070 ft.

Convection Section—The temperature of the stack gas may be obtained from Fig. 1 in the article entitled "Refinery Combustion Calculations".[2] At 20 per cent loss and at 25 per cent excess air the stack temperature is 810 deg. fahrenheit.

The temperature of the gases entering the convection section may be obtained from the same chart. The heat remaining in the gas as it leaves the convection section is 100 minus 53.5 minus 3 (loss) or 43.5 per cent. Temperature = 1700 deg. fahrenheit.

The temperature of the oil entering the section is 300 deg. fahr. and that of the oil leaving may be computed as follows:

$$2{,}860{,}000 = 30{,}000\ (t - 300)\ 0.6$$

$$t = 460 \text{ deg. fahr.}$$

Log Mean Temperature Difference = $[(1700 - 460) - (810 - 300)] / \log_e [(1700 - 460) / (810 - 300)] = 825$.

Transfer Rate—The pure convection transfer rate may be found from Fig. 1, Article 1.[1] At a flue gas velocity of 12 ft./sec. and at an average gas temperature of 1250 deg. fahr. the pure convection rate is 3.7 B.t.u./sq. ft./hr./deg. fahr.

[1]Nelson, *The Petroleum Engineer*, p. 22, April, 1933.
[2]Nelson, *The Petroleum Engineer*, p. 44, February, 1933.

TABLE I

Absorption 10,000,000 B.t.u./hr.
4-in. by 5-in. Tubes.
15 ft./sec. flue gas velocity in the simple stills.

Stills No. 1, No. 2, and No. 3—Rad. Surface 266 sq. ft. Proj. Conv. Surface 540 sq. ft. (O.D.)
Stills No. 4, No. 5, and No. 6—Rad. Surface 119 sq. ft. Proj. Conv. Surface 570 sq. ft. (O.D.)

Still Number	Recirculation	Duty ÷ 10^6		Convection Gas				Radiant Section			Eff.	Length of Tubing	Length of Tubing for Simple Still
		On Fuel	On Q or Dev.	In °F	Out °F	MTD °F	hc	Factor on Q	% of heat in fuel	Absorption rate			
1	0—1	13.3	13.3	1680	810	810	7.6	.5	50	25,000	75	1055	1055
2	0.5—1	13.3	14.7	1630	810	800	9.5	.40	44	22,100	75	1055	1105
3	1—1	13.1	15.4	1540	780	750	12.0	.325	38	19,000	76	1055	1204
4	0—1	13.3	13.3	2100	810	975	8.4	.40	40	44,700	75	720	720
5	0.5—1	13.3	14.7	1930	810	915	10.8	.311	34	38,500	75	720	720
6	1—1	13.3	15.8	1700	810	845	12.3	.24	29	32,500	75	720	802

temperature difference. The radiation from the gas may be found in Article 2 of this series.[3]

hrg — the gas rad. coefficient = $1250 \times .0025 - .5 = 2.6$.

Assume a wall effect of approximately 10 per cent:

Total Convection coefficient = $(3.7 \times 2.6)\ 1.1 = 6.95$.

Convection surface = $2{,}860{,}000/(6.95 \times 825) = 500$ sq. ft. (O.D.)

Effective length of 3-in by 4-in. tubing = 477 ft.

Total length of tubing required = $1070 + 477 = 1547$ ft.

Example Design II—Recirculation Still

All conditions and requirements are the same as in Example I except that a recirculation ratio of 1 to 1 will be used. In other words, two parts of flue gas pass through the still for each part that escapes into the stack.

Q or the heat generated in the fire box consists of two items: First, the heat contained in the fuel or 13,330,000 B.t.u./hr. and, second, the heat in the recirculated gas (20 per cent of heat in fuel). Thus the heat liberations amount to 16,000,000 B.t.u./hour.

G, the air fuel ratio, is $[(13.7 \times 1.25 + 1)2 - 1]/1 = 35.2$.

The value of the absorption rate (20,000) involves the factor R, which is not known and hence the radiation equation presented in Article 1 of this series can be solved only by trial and error methods. The solution of this question by trial and error methods is presented in Fig. 1 of this article.

R or radiation factor = 0.32 for a rate of 20,000

Radiant Surface = $(0.32 \times 16{,}000{,}000)/20{,}000 = 225$ sq. feet.

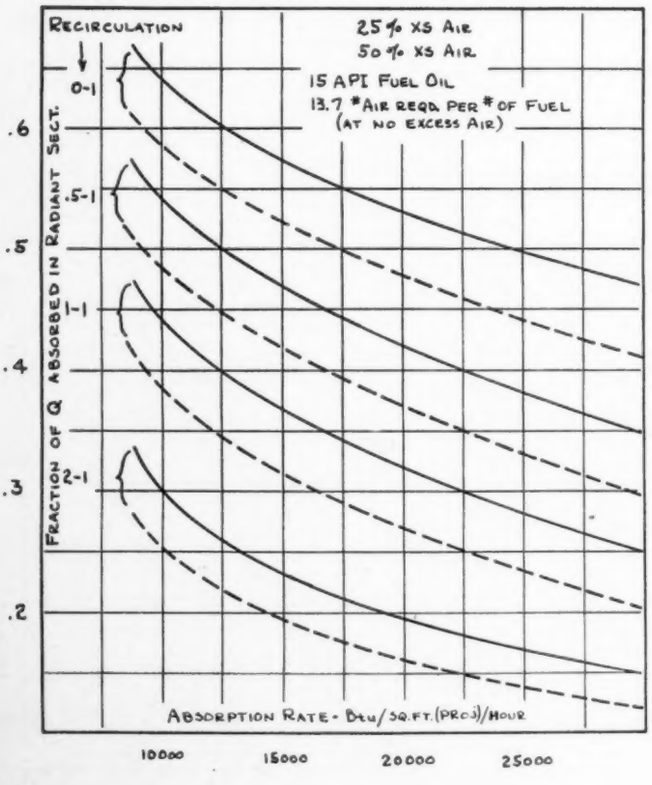
Effective length of this tubing = 770 feet.

The absorption of 32 per cent is based on the 16,000,000 B.t.u. liberated in the radiant section and not on the heat contained in the fuel. The percentage of heat absorbed in the radiant section based on the heat in the fuel is

$(0.32 \times 16{,}000{,}000)/13{,}330{,}000 = 38.4$ per cent.

[3]Nelson, *The Petroleum Engineer*, p. 30, May, 1933.

Fig. 1—Radiant absorption rate with gas recirculation



HEAT BALANCE

Efficiency	75 %	10,000,000 B.t.u.
Radiant Section	38.4%	5,120,000 B.t.u.
Convection Section Loss	36.6%	4,880,000 B.t.u.
Radiant Section Loss	3.0%	400,000 B.t.u.
Convection Section Loss	2.0%	260,000 B.t.u.
Stack Loss	20.0%	2,670,000 B.t.u.
	100.0%	13,330,000 B.t.u.

Convection Section—Gas out at 810 deg. fahr. containing 20 per cent of the heat in fuel.

Gas into convection section — (Refer Fig. 1, prev. Art.[2]) $(2300 + 810)/2$ = approx. 1555 deg. fahrenheit.

Oil out of convection section = (Refer to Example I) $(0.366/0.215 \times 160 + 300 = 570$ deg. fahrenheit.

Log mean temperature difference = 725 deg. fahrenheit.

Total transfer rate if same tube arrangement is kept in the convection (vel. = approx. 24 ft./sec.) — hc = $(7.2 + 2.25)\ 1.1 = 10.4$.

Surface = $4{,}880{,}000/(725 \times 10.4) = 647$ sq. feet.

Linear convection tubing = 620 feet.

Total length of tubing = $770 + 620 = 1390$ feet.

In general, the recirculation stills require less surface for the same efficiency than simple stills. Examples I and II illustrate this. Nevertheless, the differences in surface, in these examples 157 ft. of 3-in. by 4-in. tubing, must pay for the recirculation equipment and the gas-tight construction of the recirculation still. Thus the initial cost is usually slightly more for the recirculation still as well as a greater operating cost so that the adoption of a recirculation still rests entirely with the advantage that it affords in controlling the radiant absorption rate. Recirculation stills usually appear to more advantage than indicated in the above examples because the convection surface may be arranged for higher gas velocities on account of the forced convection system.

As a further indication of the effect of flue gas recirculation Table I represents a comparison of the efficiencies of the two types of stills. Still No. 1 was designed for no recirculation, an efficiency of 75 per cent and a radiation factor of 0.5. Stills No. 2 and No. 3 are exactly the same still as No. 1 except that the flue gas is recirculated. Stills No. 4, No. 5 and No. 6 are the same sort of a comparison except that the non-recirculating still No. 4 was designed for a radiation factor of 0.4. All the stills absorb 10,000,000 B.t.u./hr. and heat a stock from 300 deg. fahr. to 700 deg. fahrenheit. The fuel is an average liquid fuel used with 25 per cent excess air.

The final column of linear feet in Table I shows the lengths of tubing required in a simple non-recirculating still built for the same total absorption, same radiation absorption rate and the same efficiency as the stills appearing in the same line. As mentioned in Example II the radiation equation can be solved for the absorption rate (not Q) only by trial and error methods. As an aid in design the equation has been solved and plotted graphically in Fig. 1.

In the use of these articles and charts, the exact definition of the radiation factor R must be kept clearly in mind. This factor is the fraction of the total heat developed in the flame that is absorbed in the radiant section. Thus in simple stills R is a fraction of the heat contained in the fuel while in circulation stills or air preheat stills it is the fraction of the total heat liberated in the flame, which may be the sum of the heat in the fuel, the heat in the recirculated gases (above 60 deg. fahr.) and the heat in the air (above 60 deg. fahr.)

Air preheat increases the flame temperature and the rate of radiant absorption so that it tends to defeat the advantage of flue gas recirculation. Higher efficiencies can be obtained by air preheat but the same efficiency can be obtained at about the same expense by building a larger convection section in the still. At the same time the flames can be more exactly adjusted if the primary air is under a slight pressure such as in a preheat system.

* * * * * *

All combinations of motors and generators in use are variations of the Ward Leonard system

* * * * * *

Direct Current for Rotary Drilling

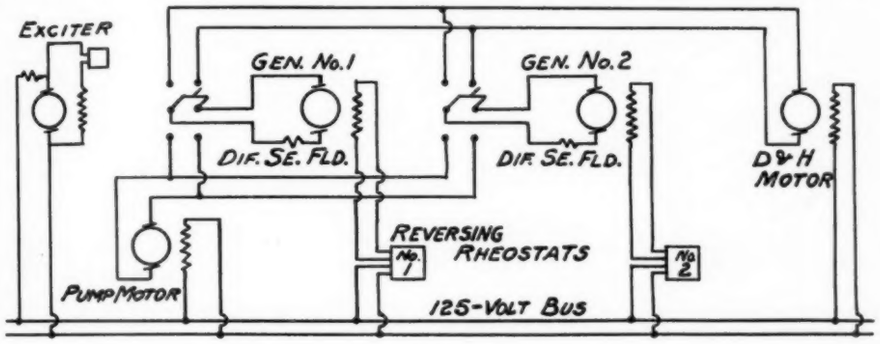
By W. C. LANE
Electrical Engineer

ELECTRIC motors having characteristics that make them adaptable to the work of rotary drilling were built many years before the first well was completed by the rotary method. As the rotary system was improved and developed, it became evident to those familiar with the operation of electrical equipment that it would not be a difficult matter to apply motors to this work. However, oil fields are not usually found adjacent to power lines so that it was not until after proven oil areas were electrified for pumping that serious attempts were made to use motors. It was natural that since the fields were served from alternating-current lines, first efforts were directed toward perfecting drives that used electrical energy in this form.

Several different types of induction motor drives have been developed that operate satisfactorily and economically but their use is limited to regions traversed by power lines. From the first, engineers have agreed that, since the major operation performed by a rotary rig is that of hoisting, direct-current apparatus is by far the more flexible and should be used in preference to alternating current. In spite of this, alternating current came into general use because it is the only form of electrical energy that can be transmitted over long distances economically. It is well known that it is impossible to step the voltage of direct current up and down. It must be generated and transmitted at a potential that should never exceed 500 volts on the well floor. The weight of the cables necessary to transmit a given amount of power at a given loss varies inversely as the square of the voltage. It is very evident that the cost of copper becomes excessive when an attempt is made to serve a drilling rig with direct current from a distance.

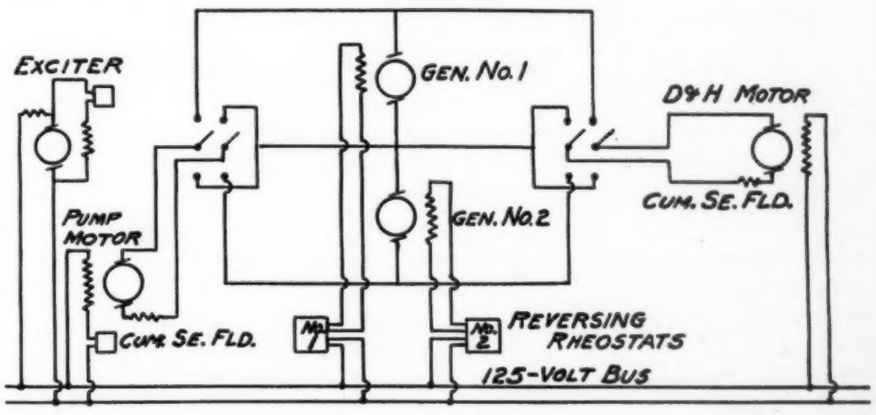
Recent developments in internal combustion engines have made it possible to assemble portable power plants in units whose weight is such that they can be transported to isolated locations without excessive expense. Both direct- and alternating-current plants that may be driven by gas, gasoline and Diesel engines have been perfected. The one advantage of the latter system over the former is that the motor equipment can be operated from central station energy should such be available. Also, in the case of the floating power plants developed for use in southern Texas and Louisiana, it is possible to anchor the power barge on a waterway and transmit power to a location inland that would be beyond the range of direct-current transmission. It does not appear that for general work these advantages offset those inherent in a direct-current installation.

Power for drilling operations must be applied at a variable speed whether it be for rigging up, rotating the bit, operating the pump, handling pipe or fishing. It is necessary that it be possible to change quickly both the speed and the torque of the drilling and hoisting motor throughout a wide range, with small increments and to reverse the direction of rotation. This can be accomplished by the use of a system developed perhaps 40 years ago by an American engineer, Ward Leonard. The system has many variations but the basic principle is common to all. In brief, it consists of separately exciting the field of a motor to be operated from a constant voltage exciter bus and energizing the armature from a special generator whose voltage can be varied from zero to maximum in small steps. That is, each motor is driven from one or more generators, which supply energy to no other load during the operation. The method is expensive to install where a large number of motors are concerned, but the cost is not excessive when applied to a drilling rig, which has only two operations taking place simultaneously.



Above—Fig. 1

Below—Fig. 2



In applying the system to a string of rotary tools the simplest combination possible includes two main generators and one small unit known as the exciter. These generators may all be driven from one engine, three separate engines or any combination of engines. Transportation difficulties and

the provisions made for stand-by service will determine this factor. While drilling, one main generator is used to drive the drilling and hoisting motor and the other to operate the pump motor. Additional units for increasing the capacity of the generating station and for guaranteeing the continuous operation of the rig are provided when the economics of drilling justifies such a course. Three manufacturers have worked out the details of operation in as many different ways. All have made provisions for combining the output of the two main generators for the hoisting motor while handling pipe.

Fig. 1 and Fig. 2 represent the basic electrical connections of the four direct-current rigs now in use in the United States. The last of these to be put out is a combination of the three earlier rigs. It will be observed that in Fig. 1 the switching arrangement is such that the two main generators can be connected in parallel for driving the drilling and hoisting motor during pulling operations while in Fig. 2 provisions are made for combining the generators in series. A motor operated by generators in parallel will carry the combined current output of the two machines, their common voltage being impressed over the armature. The speed of such a motor is changed by varying the voltage of the two generators and on light loads, the field of the motor itself may be altered. In the series system a motor is subjected to the combined voltage of the two generators, and to the current common to both. Variations of speed are obtained in the same way as that outlined above. With this system no particular difficulty is experienced when there is an unequal division of the load on the two driving engines. In both systems sparkless commutation of generators and motors is obtained by the use of series interpole windings.

The pump motor can be operated from one or two generators in either system in a manner similar to that used in the case of the hoisting and drilling motor. There will be a tendency for a pump to overspeed when it is driven by the two generators in series. This action is avoided by doubling the field strength of the motor, thus making it possible to utilize the full capacity of the two generators.

It is the custom for men of the drilling fraternity to evaluate all operations about a rig in terms of what can be accomplished with steam equipment. Theory and experiment show that any mechanical operation that can be performed with steam can be duplicated with a direct-current motor. To explain the behavior of a motor when subject to the different conditions encountered, reference is made to the fundamental motor equation (1) and (2). In applying these it must be kept in mind that the generators are driven at a constant speed by engines of ample capacity and that their voltage is under the control of the driller.

Fig. 3

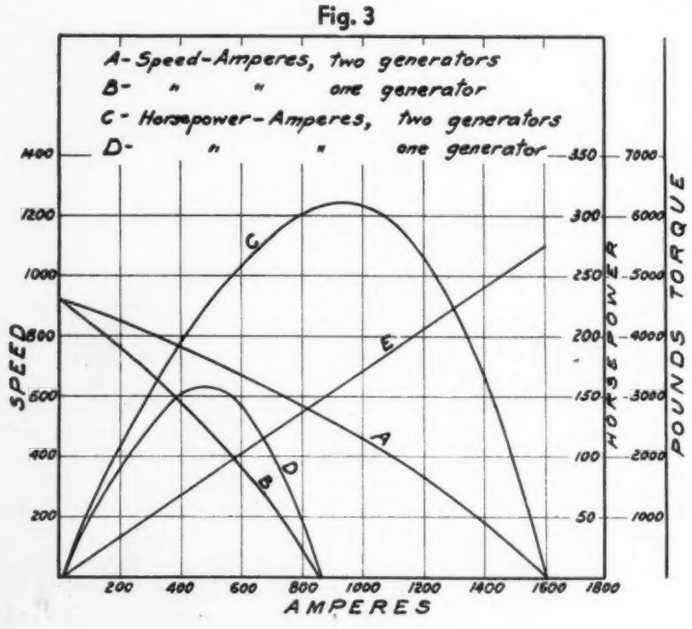
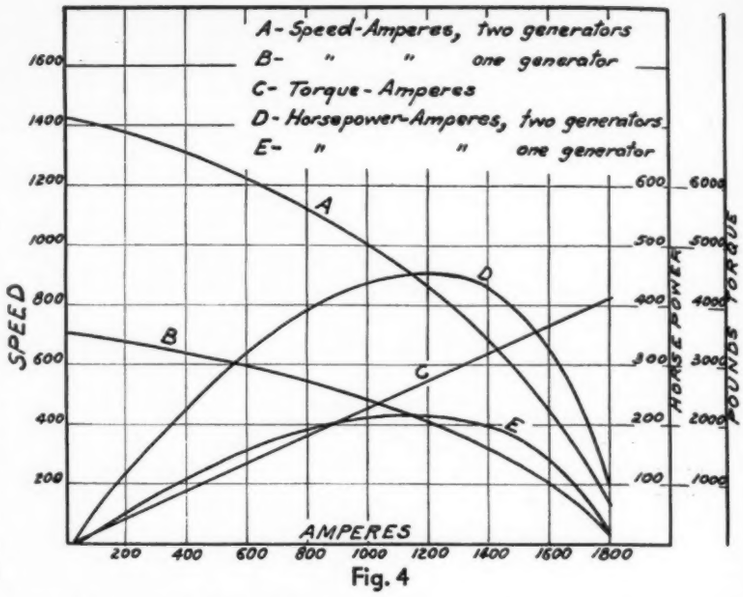


Fig. 4



(1) $T = K I N$

(2) $n = (E - IR)/KN$

E = Generator voltage applied to the motor armature
T = Torque produced by motor
K = A constant for the particular motor
I = Current supplied to the motor
N = Field strength
R = Resistance of motor armature (a small quantity)
n = Revolutions per minute of motor.

For purposes of analysis, assume that since R is small, IR in equation (2) may be neglected and that the motor field, N, is kept constant. In starting a heavy load such as a frozen string of drill pipe, the generator voltage is increased gradually, thus causing an increasing current, I, to flow in the armature of the motor. As I increases, T in equation (1) increases and will continue to do so up to the capacity of the generator. When the load starts to move the current will decrease automatically. The voltage may then be further increased and the load accelerated at the will of the driller. It can be seen from equation (1) that a motor will exert its maximum torque at rest or at any speed desired, providing the voltage is given the proper value. An ammeter in the armature circuit of a motor will give an absolute indication of the pull it is exerting.

In rotating the table or driving the pump the voltage is adjusted to a value which, in equation (2), will give the desired speed. The efficiency of a motor under this condition is high as there is no rheostat such as is found in the rotor circuit of an alternating-current motor to dissipate heat. A plugged bit may be cleared by using the same method as that applied to frozen pipe. The proper method to use is to increase the voltage slowly and observe the reading of the gauge on the mud line.

A point about which there is much discussion is the relative merits of the series and parallel systems under

(Continued on Page 51)

Some Principles of Fluid Flow

By WAYNE C. EDMISTER

Research Engineer

THE phenomenon of flow of fluids in pipes has been divided into two classes, viscous or straight line flow and turbulent flow. Their names adequately describe them and the conditions of flow in both cases may be expressed by the same formula, if expressed in terms of a friction factor which is itself determined by the condition of flow.

Let ΔH be the drop in head in feet of the fluid in a line L ft. long. The volume of ΔH is expressed as a function of $V^2/2g$ or

$$\Delta H = (fL)m \times (V^2/2g) \quad . \quad . \quad . \quad . \quad (1)$$

If Δp be the drop in pressure in pounds per sq ft. in L feet,

$$\Delta p = f\rho LV^2/2gm = 2f\rho LV^2/gd \quad . \quad . \quad (2)$$

where:

ΔH = the drop in head in ft. of fluid = $\Delta p/\rho$

Δp = the drop in pressure in lb./sq. ft.

ρ = the density in lb./cu. ft. = 62.3 S

S = the specific gravity relative to water.

L = the length in ft. plus extra length due to elbows.

V = velocity in ft./sec. (average) = $Q/\pi d^2/4$

Q = flow in cu. ft./sec.

d = diameter (inside) in feet

D = diameter (inside) in inches

m = hydraulic radius in ft. = area of cross section in sq. ft. divided by the wetted perimeter in ft. = 4/4 for circular pipes.

f = friction factor (no units)

P = drop in pressure in lb./sq. in. in L feet

$\Delta p = 144 \times \Delta P$.

Equation 2 may be expressed as follows by making substitutions:

$$\Delta P = 2f \times 62.3 \times SLV^2/14g(D/12)$$

$$\Delta P = 0.333\, f \times SLV^2/D \quad . \quad . \quad . \quad . \quad (3)$$

Equations 1, 2 and 3 are known as the Fanning Formulae (formula 3 probably being the best known) and hold for both viscous and turbulent flow. The friction factor "f" for viscous flow is a linear function of the ratio DVS/Z or the pipe

(Continued on page 52)

(Continued from Page 50)

the conditions that arise when one unit is shut down and hoisting work is done with a motor driven from a single generator. If the generators have the same capacity, why are they not equally effective in handling a load? From equation (1), it can be seen that when the motor field is constant, the torque is a direct function of the current and is independent of the speed. A motor operated from the current produced by one generator will produce the same torque as when operated from two connected in series. However, the speed will be only one-half as great. The same motor operated from two generators connected in parallel under similar load conditions will have double the current supplied to it that it does when one of these is out of service. With one generator carrying the load only one-half of the current can be supplied so that half the torque will be produced but the speed will be the same since the impressed voltage is unaltered (equation 2). The way this torque can be made to do the same work is to change speeds on the draw-works as shifting from high-low to low-low. It must be kept in mind that a fair comparison of competitive motors can be made only when the same method is used in rating them. This must be on the basis of load and temperature rise and not on torque alone.

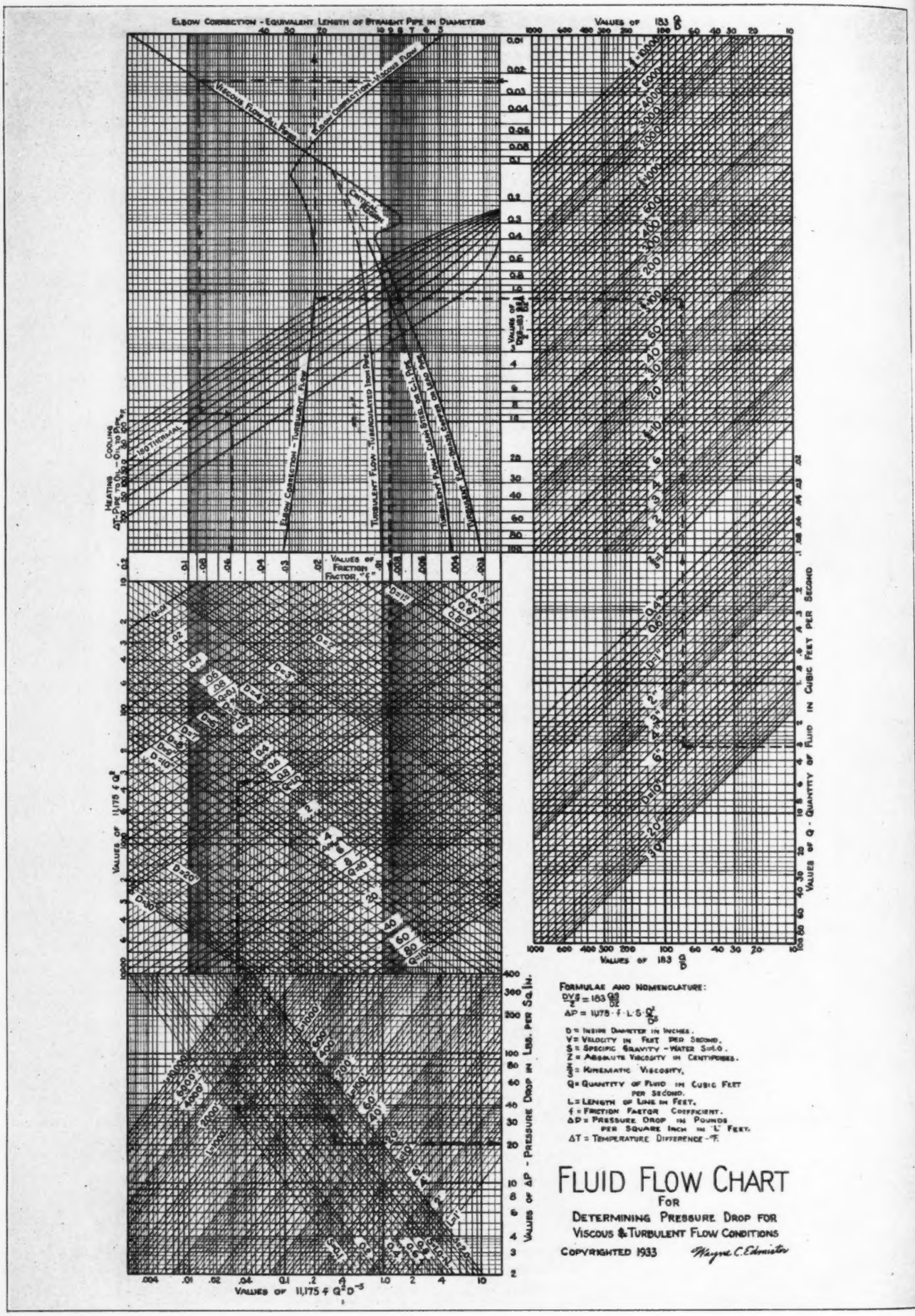
The curves shown in Fig. 3 and Fig. 4 are representative of the characteristics of hoist motors now in service on direct-current installations. In checking the points brought out above, it must not be forgotten that the two rigs operated with these motors will not use the same ratio of speed change so the slower-speed motor will need more torque in order to accomplish the same results.

Overload protection for the engines and pumps is provided by applying cumulative and differential series windings to motors and generators in diverse ways. A cumulative series winding will cause the field to increase with an increase of load. In a generator this will cause the voltage to rise, while with a motor it causes the speed to fall. Differently connected fields have exactly the opposite effect. When an overload comes on a generator equipped with a series differential field set for a given load, it will be impossible to overload the engine so that it will stall. Beyond a certain load the differential field overpowers the separately excited shunt field so that the voltage drops. Beyond this point the output of the generators, volts times amperes, gets smaller. For pulling work the ideal arrangement is to have a combination of rig equipment that will enable the driller to keep the engines loaded under all conditions.

Where a pump motor is provided with a cumulative series winding it will slow down under load automatically, thus tending to prevent the occurrence of excessive pressure. A shunt-motor driven by a differential generator will behave in the same way. The use of differential series fields makes it possible to operate the two direct-current generators in parallel and maintain a proper load division in spite of the tendency of the engines to shift the load back and forth.

One manufacturer uses separately excited shunt generators and cumulative compound motors; a second uses generators with a separately excited shunt and a differentially connected series field and shunt motors; a third manufacturer uses a combination of those used by the other two with additional features. All these combinations are being operated successfully but at this stage of development it is not evident that the basic ideas of any one are greatly superior to those used by the other two.

The combination of direct-current apparatus with internal combustion engines makes a very efficient installation that is independent of an outside source of power, is portable and has all the flexibility of a rig operated by steam. Motor designs are such that fire hazards have been eliminated and experience thus far indicates that the upkeep of the electrical apparatus is very low. Little water is used other than that which goes down the hole and which may be of a poor quality. Much less fuel is handled than that consumed by a steam rig and the choice of the fuel to be used is governed by the cost. Existing rigs have drilled to depths greater than 5100 ft. and it appears that they will soon be in common use in both wildcat and proven territory.


Elbow Correction - Equivalent Length of Straight Pipe in Diameters
Values of 183 g/D
Values of Friction Factor "f"
Values of 11,175 f Q²
Values of 11,175 f Q² D⁻⁵
Values of ΔP - Pressure Drop in Lbs. per Sq. In.
Values of Q - Quantity of Fluid in Cubic Feet per Second
Values of 183 Q/D
Viscous Flow - Laminar Flow
Turbulent Flow - Unobstructed Pipe
Turbulent Flow - Commercial Pipe
Elbow Correction - Viscous Flow
Elbow Correction - Turbulent Flow
Heating ΔT - Pipe to Oil - Oil to Pipe °F
Cooling
Isothermal
Formulae and Nomenclature:
ΔP = 11.75 · f · L · S · Q² / D⁵
D = Inside Diameter in Inches.
V = Velocity in Feet per Second.
S = Specific Gravity - Water = 1.0.
Z = Absolute Viscosity in Centipoises.
ν = Kinematic Viscosity.
Q = Quantity of Fluid in Cubic Feet per Second.
L = Length of Line in Feet.
f = Friction Factor Coefficient.
ΔP = Pressure Drop in Pounds per Square Inch in 'L' Feet.
ΔT = Temperature Difference - °F.
Fluid Flow Chart
For
Determining Pressure Drop for Viscous & Turbulent Flow Conditions
Copyrighted 1933
Wayne C. Edmister

modulus. If in equation 2, "f" is set equal to $16\mu/dV\rho$, Poiseuille's formula for straight line flow is obtained.

$$\Delta p = 32\mu LV/gd^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where:

μ = absolute viscosity in English units
Z = absolute viscosity in centipoises
$\mu = 0.000672 \times Z$
$f = 16\mu/dV\rho = (16 \times 0.000672/62.3)\ Z/VS(D/12)$
$= 0.00207\ Z/DVS.$

Poiseiulle's formula may be expressed in different terms by substituting in Equation 3 the value of 0.00207 Z/DVS for "f."

$$\Delta P = 0.000668 \times ZLV/D^2 \quad . \quad . \quad . \quad (5)$$

Equations 4 and 5 are Poiseuille's formulae, in different terms and hold for viscuous flow only.

Let Q be the quantity of fluid flowing in cu. ft. per second.

$Q = V\pi D^2/4 \times 144;\ V = 576\ Q/\pi D^2$

or—

$V^2 = (576/\pi)^2\ (Q^2/D^4)$

Substituting for V^2 in Equation 3:

$\Delta P = 0.333\ (576/\pi)^2\ (Q^2/D^4)\ (fLS/D)$

$$\Delta P = 11{,}175\ fLS\ (Q^2/D^5) \quad . \quad . \quad . \quad . \quad (6)$$

The friction factor "f" is a function of DVS/Z. For viscous flow $f = 0.00207\ Z/DVS$. For turbulent flow the values of the friction factor "f" have been found experimentally and plotted against DVS/Z, which is known as the pipe modulus and by substituting for V, its value will be in terms of Q.

$V = 576\ Q/\pi D^2$
$DVS/Z = (DS/Z)\ (576/\pi)\ (Q/D^2)$
$DVS/Z = 183\ QS/DZ.$

The right-hand side of the chart gives values of DVS/Z for Q from 0.02 to 100 cu. ft./sec., Z/S from 1.0 to 10,000 (Z/S is the kinematic viscosity), by multiplying Q by 183/D and dividing by Z/S.

In the upper left section values of the friction factor "f" are plotted against the pipe modulus DVS/Z, for isothermal flow. The straight line marked "Viscous Flow—All Pipes" is the plot of $f = 0.00207\ Z/DVS$ and gives friction factor for all pipes regardless of roughness. The three curves, which give the values of the friction factor for turbulent flow, are for different types of pipe walls. It has been found that the roughness to be considered in the pipe wall is the relative roughness. That is, the rough parts would have more effect on a 1-in. pipe than the same type of rough parts on a 12-in. pipe. The use of this chart then makes it necessary to determine under which classification the pipe in question falls. Values of "f" plotted for turbulent flow are for pipes as classified for sizes 2-in. to 8-in., inclusive. With a much larger size it would be necessary to put it in the classification of a smoother pipe and vice versa; with a much smaller pipe it would be necessary to treat it as a rougher pipe. This variation will become appreciable in the extreme sizes.

The values of "f" given are normal for isothermal flow; that is, the temperature of the pipe wall is the same as the body of the oil or fluid. If on the other hand, the oil is being heated or cooled as it flows in the pipe, the film temperature will not be the same as the temperature of the body of the oil, consequently the film viscosity will not be the same as the viscosity of the body of the fluid. Keevil and McAdams (Chem. and Met. Vol. 36, No. 8, 1929) present results of tests for friction factor for heating and cooling friction flow factors. The heating and cooling correction lines in the upper left-hand section are crude corrections based on these data.

If the pipe modulus DVS/Z is 0.023 for a pipe in which oil is being heated and the difference in temperature between the pipe wall and the body of the fluid is 100 deg. fahr. the friction factor "f" may be found as follows: Enter the upper left-hand section of the chart with DVS/Z = 0.023 and follow the arrows. Turn at the viscous flow line, go to Normal-Isothermal line, turn again, go to $\Delta T = 100$ deg. fahr. line, turn and read the friction factor as 0.06. If heating correction had not been made, the friction factor would have been found as 0.087, which would have given an erroneous pressure drop.

The upper left-hand section gives also the elbow corrections, in equivalent length of straight pipe in diameters, plotted against DVS/Z. This elbow correction factor is a different curve for viscous and turbulent flow as does the friction factor.

Equation 6 is graphically represented in the lower left-hand section of the chart. Starting with "f" the equation is solved by multiplying by 11,175 Q^2, dividing by D^5 in the top part, then multiplying by L and making the gravity correction in lower part of section, thus getting the drop in pressure. The chart is normal for a gravity of S = 1.0.

An example will show the use of the "Fluid Flow Chart." It is desired to flow isothermally 3.2 cu. ft. of oil per second, having a gravity of 0.75, a kinematic viscosity of 65, through an 8-in. cast-iron pipe 1000 ft. long. Enter the chart on the right-hand side on Q scale with Q = 3.2 and follow the arrows. Go along the Q = 3.2 line to D = 8, giving a value of 183 Q/D of 73; turn and go along this line to Z/S = 65, turn and go to DVS/Z = 1.15 on scale. With this value of the pipe modulus, and no correction due to temperature drop, the friction factor is found in the upper left-hand section to be 0.0092. The elbow correction is likewise found in this section to be 22. With "f" = 0.0092 go to Q = 3.2 line in the top part of the lower section, giving the value of 11,175 f Q^2 as 3400, go along this line to D = 8″, turn and go down to bottom section where reading of 11,175 f Q^2 D^{-5} is 0.034. Go along this line to L = 1000 ft., turn and go to S = 1.0 — N, turn and go to S = 0.65, turn and go to the pressure drop scale, getting P = 20.5 lb./sq. inch.

Continental Supply to Move Headquarters to Dallas

The Continental Supply Company in the near future will move its headquarters from St. Louis, Mo., to Dallas, Texas, according to a recent announcement. At present the general office employs about 150 people, a large number of which will be moved to Dallas.

This company was organized 21 years ago and in addition to distributing pipe and other materials manufactured by the Youngstown Sheet and Tube Company, it is the exclusive agent in the Mid-Contingent region for the distribution of oil well drilling machinery and pumping equipment manufactured by the Emsco Derrick and Equipment Company of Los Angeles and Dallas, and for many other large manufacturers.

W. J. Morris, president, said, in discussing the company's choice of a new location:

"The officers and directors have felt for some time that the general offices of the company should be located at a point more central to its activities. After months of investigation it was decided that Dallas, being practically the geographic center of the present oil producing territory, the interests of the customers of the Continental Supply Company could be better served by having its general offices located at that point."

Officers of the company who will move to Dallas are: William J. Morris, president; F. L. Brinegar, assistant to the president; F. M. Mayer, vice-president and treasurer; B. K. Kelly, assistant treasurer; C. A. Gutgesell, assistant treasurer; C. H. Meyer, manager of sales; H. E. Spencer, director of purchases, and A. J. Olson, manager of machinery department.

ROBERT L. BLAFFER, former vice-president, has been elected president of the Humble Oil & Refining Company to succeed William S. Farish, who resigned to become chairman of the Standard Oil Company of New Jersey, parent organization. The directors also created the post of executive vice-president and named Harry C. Wiess, former vice-president in charge of refineries and sales, to fill it. Mr. Blaffer assisted Mr. Farish and Ross S. Sterling in organizing the Humble Company in 1917, and has served as vice-president since that time.

E. J. RILEY, president of the Smith Separator Company, Tulsa, Okla., is the father of a baby girl, born June 3.

L. V. NICHOLAS, who served from 1921 to 1928 as president of the National Petroleum Marketers' Association and since that time as a consultant and adviser in industrial problems, has been elected president of the Warner-Quinlan Company, New York City. He succeeds W. W. MacFarland, who remains as vice-president.

W. H. BOWDEN, prominent power engineer of the oil industry, who for many years has specialized in central pumping powers, has joined the firm of Dewey T. Ross, Inc., Tyler, Texas. This company, which was recently incorporated, is specializing in designing, constructing and completing pumping installations in the East Texas field. Mr. Ross before engaging in this type of work a year ago was construction engineer for the Shell Petroleum Corporation.

NEAL H. ANDERSON, formerly oil umpire for the State of California, recently visited the Oklahoma City oil field. He was accompanied by a group of Selby Oil & Gas Company officials from Tulsa, Okla. While in Oklahoma City, the party was entertained by R. C. Grinnell of the Fluid Packed Pump Company. Anderson and the Selby officials then visited the Kansas oil fields, from where Mr. Anderson returned to the coast.

S. R. SETSER has been appointed field salesman for the Oil Center Tool Company, Houston, Texas. He was formerly with J. H. McEvoy & Company, prior to which time he was field superintendent in the Humble, Texas, district for the Humble Oil & Refining Company.

A. F. ZOLL, refinery plant superintendent for the White Star Refining Company, has been moved from Trenton, Mich., to Grosse Isle, Michigan.

C. E. REED, who some time ago assumed the general direction of manufacturing drilling bits for the Chicago Pneumatic Tool Company, New York City, has now been placed in charge of the company's sales force in the field. Mr. Reed has been exclusively engaged in the design of cone and rotary type of roller bits since 1912. His inventions, comprising roller bits, reamers and Tucone bits, are in world-wide use. Mr. Reed will maintain his home and headquarters at Wichita, Kansas.

F. E. COURSON, independent producer, has moved from Jackson, Miss., to Hattiesburg, Mississippi.

JOE GORDON, formerly with Black, Sivalls & Bryson and previously with Pure Oil Company, has left the United States to join the Lago Petroleum Corporation at Maracaibo, Venezuela.

C. F. NELSON, mechanical engineer, formerly a member of the Rumely engineering staff, has recently joined the Fred E. Cooper organization in Tulsa, where he is aiding in developing a new line of winches for the Allis-Chalmers line of tractors and motors for skid units. At the completion of this work he will assume the duties of sales engineer. Prior to joining the Cooper organization he was actively engaged in the mechanical engineering and its allied phases for a period of 24 years, during which time he was in direct contact with many major developments.

WILLIAM F. HUMPHREY, former president of the Tide Water Oil Company, has been elected president of the Tide Water Associated Oil Company and to the new position of chairman of the board of the Tide Water Oil Company. Axtell J. Byles, former president of the Tide Water Associated Oil Company, recently resigned to take over his duties as president of the American Petroleum Institute. E. L. Shea, executive vice-president of the Tide Water Oil Company, was selected as Mr. Humphrey's successor as president of that company. Edward H. Salrin, a vice-president and director of the Tide Water Oil Company, was elected a director of the Tide Water Associated to succeed Mr. Byles. Alden Anderson, director of the Associated Oil Company, which is controlled by Tide Water Associated, was elected a director of Tide Water Associated to succeed Jackson E. Reynolds, resigned.

"SPEEDY" FAST, field sales representative for the Oil Well Supply Company, is again making his headquarters in the East Texas field and is maintaining his home at Tyler, Texas.

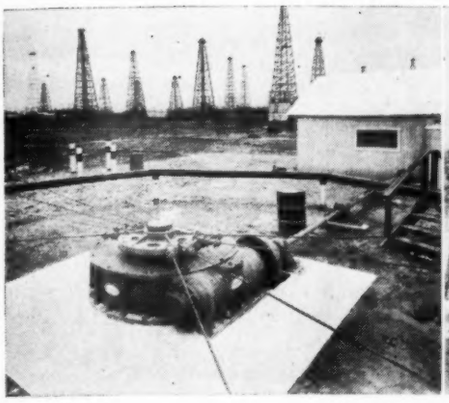
R. CHANEY, production field foreman for the Mid-Kansas Oil & Gas Company, has been transferred to Cement, Okla., from Shidler, Oklahoma.

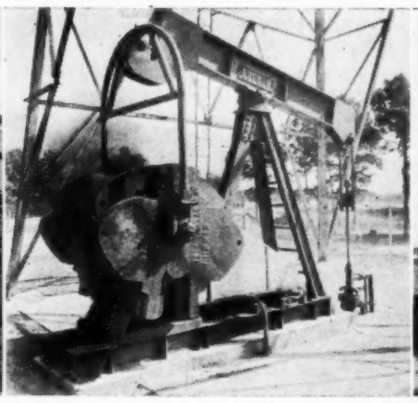
RALPH CHAMBERLAIN, Mid-Continent representative for the Ridge Tool Company, was a recent visitor in the active oil areas of Texas.

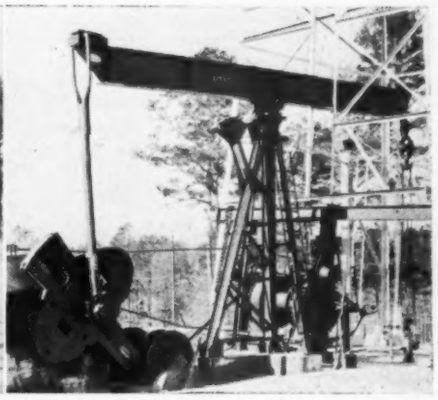
BERT ALLEN, who has been in charge of Snowden-McSweeney Company's production division, with the exception of East Texas, has been placed in charge of production in the latter district also. He expects to move his headquarters from Tulsa, Okla., to Fort Worth, Tex., in the near future.

WILLIAM V. VIETTI, petroleum engineer for The Texas Company, has been transferred from the Cisco, Texas, district to the Houston, Texas, district.

Lufkin East Texas Pumping Equipment







THE enormity of the East Texas oil field presents a variety of pumping problems unlike any other oil field in the world. Almost all of the extreme individual pumping problems of other fields will be found here. Paraffin, low pressures, salt water, swampy land and river bottom problems are common in this field.

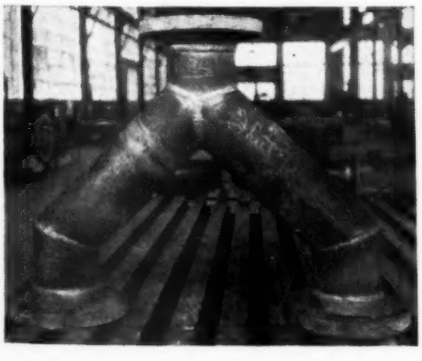
To this end Lufkin engineers have for the past two years been developing equipment to meet these individual problems. A complete line is now obtainable in both worm and herringbone gear units that will meet all East Texas conditions. Four sizes of worm gear units in 11 different types of hook-ups; five sizes of herringbone gear units with 17 different types of installations, exclusive of four types of herringbone gear self contained portable derrick for units, both single and double reduction herringbone gears with two sizes each of worm and herringbone gear central pumping powers with several sizes of well jacks, rod swings, multipliers, knockout posts, rod pendulum arms and rocker arms to complete the line.

Units adaptable to any of several types of electric motors, multiple cylinder and single sylinder gas engine drives and wells completely equipped with hoist for individual well service; or drives especially adapted for pumping purposes only when portable well service is used, are obtainable.

The Lufkin Foundry & Machine Company, Lufkin, Texas, has been pioneers and leaders in oil well geared pumping equipment for the past 12 years and is prepared to offer the excellent service of only two hours delivery from factory to the center of the East Texas field.

High Pressure Manifolds Now Built With Shielded Arc Process

HIGH-PRESSURE manifolds which must withstand a pressure of 800 lb. per sq. in. are now fabricated by the shielded arc process. One of these units is shown in the accompanying photograph, and while in appearance it differs little from any other welded piping, the factor of safety must be extremely high, because of the material carried.



The manifolds are used in petroleum distributing stations and have so far been installed in 14 sizes and types, including the "Christmas Tree" type manifold which receives exceptionally heavy service.

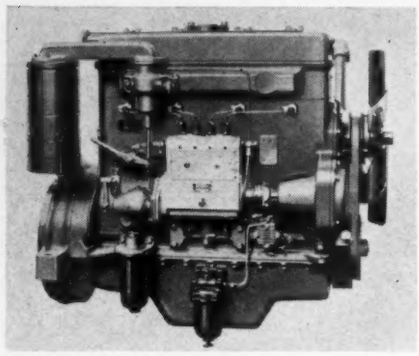
In building manifolds of this type for the Yount-Lee Pipe Line Company, the Midwest Piping and Supply Company took great care to insure close fitting of the pipe sections before welding and proper penetration of weld metal. The welding was done with a Lincoln "Stable Arc" welder and "Fleetwood" electrodes which utilize the shielded arc process.

Waukesha Licensed Hesselman Manufacturer

THE WAUKESHA MOTOR COMPANY has just concluded license arrangements with the Hesselman Company of Stockholm, Sweden, for the American rights under the Hesselman oil engine patents. Under these patents, they will manufacture a line of heavy oil engines for truck, tractor, and general industrial service. The Ingersoll-Rand Company has held a similar license for use in portable air compressors, and for more than a year these engines, built by the Waukesha Motor Company, have been on the market.

Hesselman engines occupy a place midway between the automotive Diesel engine and the gasoline engine. They burn the same fuels as a Diesel engine, but use electric ignition. They show

slightly less fuel economy, but they weigh less so that in automotive work, they are on almost even terms.

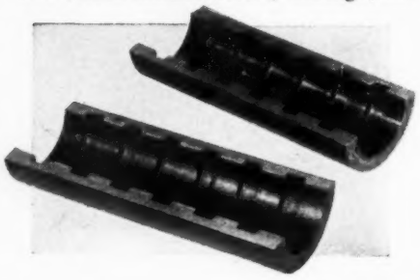


The Hesselman cycle is a distinctly different principle from any of the previous heavy fuel oil engine cycles. Its operation is extremely simple and readily understood. On the intake stroke, the cylinder is filled with air only, the amount being metered through a balanced throttling valve, and proportioned to the load requirements. A specially designed intake valve directs the air and imparts to it a rotary movement in the cylinder. The air is compressed to a greater degree than in a gasoline engine, but not to the same extent as in a Diesel. At the top of the compression stroke, a high-pressure Bosch injection pump delivers a quantity of heavy fuel, the correct amount to insure complete combustion being controlled by mechanical linkage with the air throttle. The fuel is injected through special Hesselman injectors, which throw it into the rotating air stream, where the fuel mist is intimately mixed with the air. At this moment, the spark plug fires the fuel mixture. The unusual success of this cycle is said to be due to the special features which keep the mixture ratio in the zone surrounding the spark plug always within the necessary limits for instantaneous combustion independent of the engine load or speed. At the end of the power stroke, the exhaust valve opens and releases the burned mixture, and the cycle is repeated.

A 40-hp. Hesselman engine can show an economy of 0.53 pounds fuel per brake hp. hr.—the equivalent of about 14 hp. hr. per gallon. At the prevailing price of heavy fuels suitable for operation with this engine, this represents a great operating economy, and it is easily possible to show savings in a short time that will offset the original first cost. Hesselman engines will not smoke either on quick acceleration or on overloads.

Moulded Non-Metallic Bearings

GATKE bearings are now available in a complete line for all general machinery uses, according to an announcement of the Gatke Corporation, 228 North LaSalle Street, Chicago, Ill.



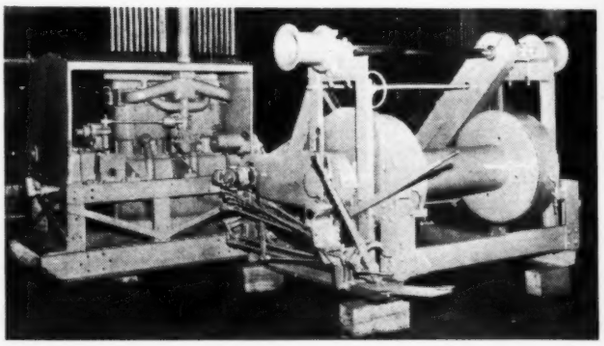
Gatke non-metallic bearings are composed of a special textile base impregnated with synthetic resins, moulded under high pressures and manufactured in all shapes and sizes. They are moulded of three basically different materials for various services, known as Gatke Hydrotex, Gatke Lubritex and Gatke Grafitex.

The Hydrotex beaings are recommended by the manufacturer for use wherever bearings are run in water or where water is available for lubrication. Gatke Lubritex bearings are designed for oil lubicated equirpment. Gatke Grafitex is self-lubricating and especially made for slow-moving machinery where dirt and grit are encountered or where lubrication is neglected.

The manufacturers claim these materials have an extremely high tensile and shear strength and a tremendous pressure resistance, although the weight is much smaller than most bearing material. It is further claimed that they are not affected by ordinary acids, solvents or salt water.

Portable Rotary Draw Works

THE WILSON MANUFACTURING COMPANY of Wichita Falls, Tex., is manufacturing a new type of portable rotary draw works. It is available in two sizes, the super model being equipped with 32-in. steel wheels and 8-in. width dual wrap, equalized and self-energizing brakes on special alloy nickel-iron brake rings.



Both models are equipped with Wilson Manufacturing Company's 6-speed forward and reverse transmission and with an independent jack shaft rotary drive. The drums are equipped with Timken roller bearings and the shafts are made of 3140 S.A.E. chrome nickel, heat treated and of ample size for heaviest loads. Prime movers may be hooked in tandem so either engine can operate draw works or pump. Any power, such as steam, gasoline, gas, Diesel or electric motors, may be applied.

Full details of this new portable rotary draw works may be obtained from the Wilson Manufacturing Company.

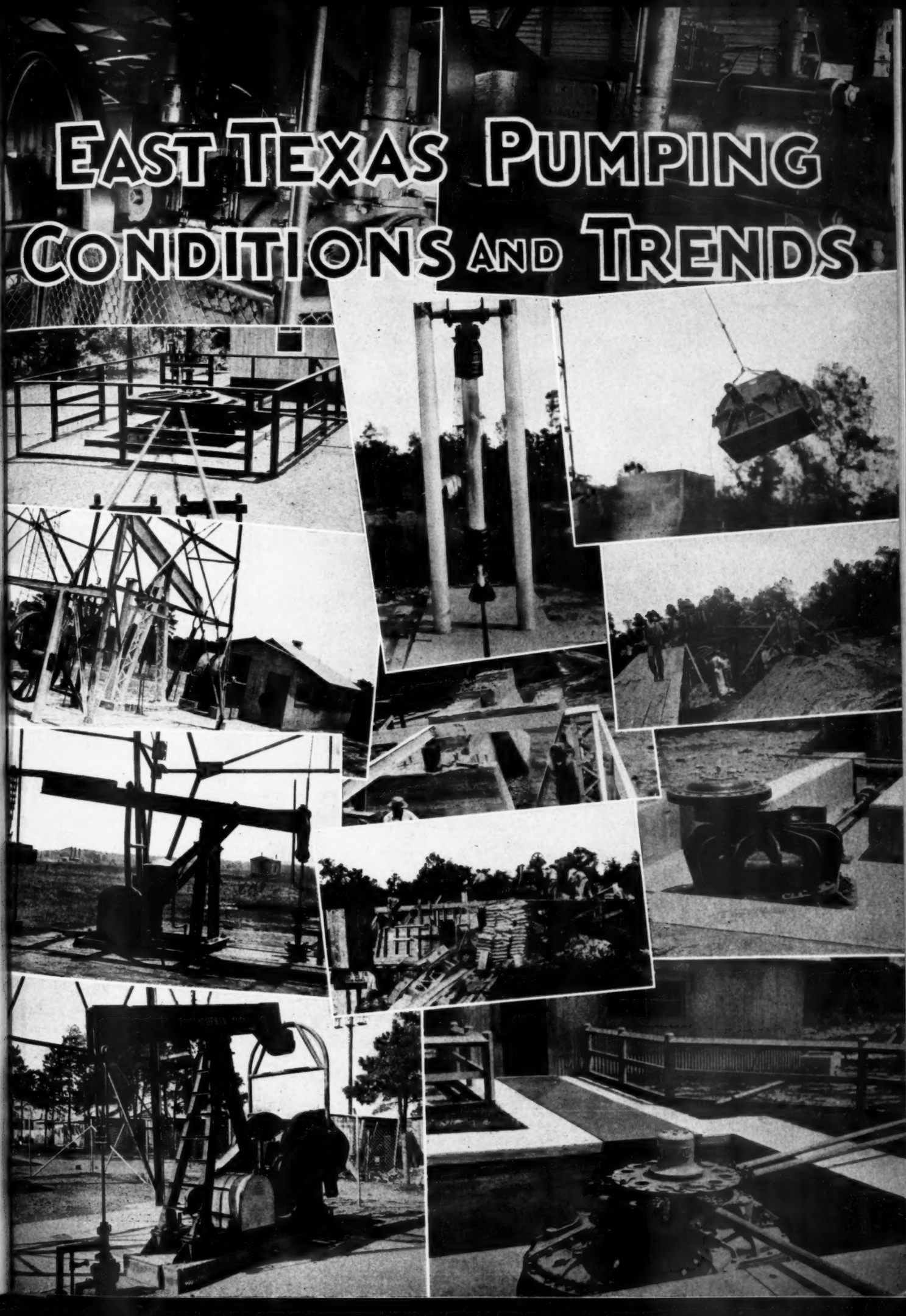
Beaird Corporation at Shreveport Will Manufacture Pumping Equipment

THE BEAIRD CORPORATION at Shreveport, La., manufacturers of oil field equipment for the Gulf Coast area, is now engaged in the manufacture of pumping equipment particularly adapted for use in East Texas. The line will include steel derricks, standard rigs, steel walking beams, rotary counterbalanced cranks and counter-balances, rig irons, band wheels, bull wheels, tubing hoists, pumping crown blocks and pumping jacks.

The new activities are under the direct supervision of S. B. Creamer, who has recently joined the Beaird organization after more than 10 years' practical experience in the design, manufacture and sale of oil field equipment. Creamer is a graduate engineer, amply qualified to direct these new activities of The Beaird Corporation.

The corporation maintains a warehouse and a representative on the Longview-Gladewater highway in the heart of the East Texas oil field.

EAST TEXAS PUMPING CONDITIONS AND TRENDS



On the pump *Electrically*

Electric
installation cost
is *lower* . . . .

Electric
operating cost
is *lower* . . . .

Electric
maintenance cost
is *lower* . . . .

Electric
performance is
uniform and
dependable . .

●

WHEN you equip for pumping you wish to obtain the utmost in overall economical operation. Consider, then, electric power. You can not afford to overlook its advantages, especially in view of the prevailing reasonable electric power rates.

Electricity possesses all the ideal features required for oil field service — low installation costs, low operating and maintenance, freedom from shutdowns, and uniform dependable performance, day in and day out. It is instantly available at the turn of a switch without incurring stand-by losses.

Electric power offers advantages in analyzing your pumping conditions and in making accurate measurements at a minimum cost. It is a recognized fact that steady well operation is conducive to maintaining the bottom of the well in the best condition, and, in the long run, cuts down rod trouble and gives maximum uninterrupted well operation, thus maintaining a high daily rate of production with a minimum lifting cost.

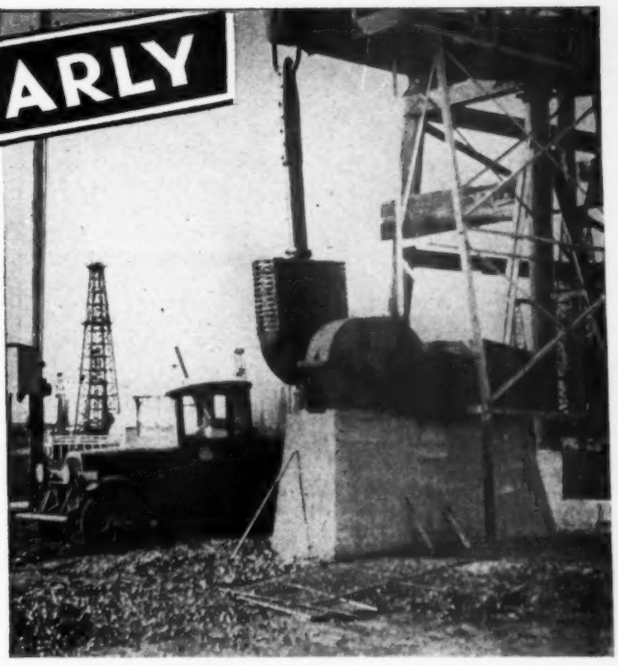
Electricity IS Cheaper

Texas Power & Light Co.

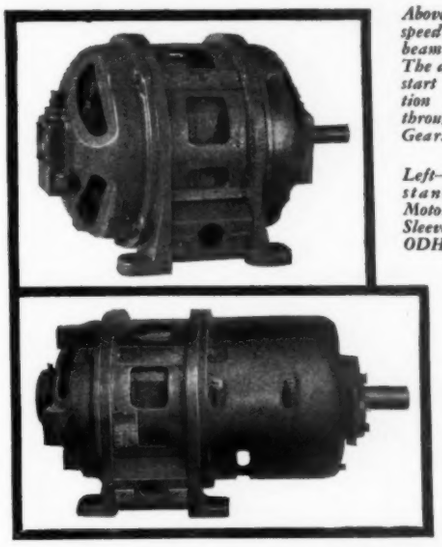
$1416 SAVED YEARLY

by

SLOW-SPEED ELECTRIC *Pumping* ON 94-BARREL WELL



Above—Westinghouse slow-speed electric drive on a beam well in California. The drive consists of a Line-start Squirrel-cage Induction Motor connected through V-belt to ODH Gear.



Left—Standard type CS Constant Speed Squirrel-cage Motor equipped with Sealed Sleeve Bearings for driving ODH Pumping Units.

The new Westinghouse Gearmotor is suitable for converting present drives to slow stroke pumping.

BY reducing the pumping speed on a certain 94-barrel well from 27 to 10 strokes per minute, power input to the motor was decreased from 13.85 to 7.2 horsepower. This saving in power consumption plus the reduction that resulted in labor and maintenance charges, gives a total yearly saving of $1,416. In addition, shutdowns due to mechanical failures were reduced by 84 per cent.

Slow-speed electric pumping has other advantages. There is a greater production of "clean" oil because less emulsification occurs—this reduces dehydration costs. There is less wear and tear on rig and below-ground equipment, and less shut-down time. Cost of equipment and materials also is lower.

For slow-speed pumping of *heavy producers* at high volumetric efficiency and low cost, Westinghouse offers the ODH pumping unit, complete with gears, motor, and control for pumping speeds as low as two strokes per minute.

Westinghouse oil field equipment is distributed by the Oil Well Supply Company and, with the exception of reduction gears, by the National Supply Companies, with offices and stores in all oil fields.

T 79274 **Westinghouse**

Quality workmanship guarantees every Westinghouse product

Cumulative production of field to date in excess of 320,000,000 barrels

On these and following pages of this issue is presented a group of special articles dealing with pumping conditions and trends in the East Texas field. That area during the next few months will undergo a rapid change for it is now in the transition stage between flowing and pumping. In order that our readers can keep informed and have the latest information on activities there this special pumping feature will be continued for a few months in The Petroleum Engineer.

By K. C. SCLATER

Past History and Present S

IN the closing months of 1929 and the first half of 1930, although drilling activities in general were at a low ebb, the menace of flush oil from new fields seemed to be gradually passing from the picture. Slowly but painfully the oil industry was recovering from the ills of overproduction that followed development of the Seminole and the Oklahoma City fields. Enforcement of proration in the latter was in the throes of bitter dispute, flagrant violations of proration regulations were many, and withdrawals from the field so heavy that the effects, detrimental to the future productivity of the field, were beginning to be felt. As a result the potential threat of this field had already begun to fade on the economic horizon.

Then in September, 1930, the East Texas field was discovered. It was not until several months later, however, that the enormous extent and possibilities of this field became generally apparent. Soon the rush was on; the lull in drilling activity elsewhere served only to stimulate greater interest in the area, and to attract operators in greater number to the new scene of activity. So easy were the formations to drill and so favorable the other conditions for small-scale operations requiring only limited capital that intensive development of the field followed as a natural result. The prolific yield, the vast number of wells, the absence of dry holes, and the resultant rapidly mounting daily production that could not be controlled and seemed for a time to have no limit, all combined to make the East Texas field the nemesis of the oil industry. Having turned out to be a potent disturbing factor that has thus far rendered futile, attempts to attain some measure of economic stability in the production of an essential raw material, the course of events in the East Texas field has become a factor to be reckoned with in terms of its effect on the future economic welfare of the entire oil industry. On what happens in East Texas in the near future hinges the question of a quick return to a normal healthy condition in all branches of the industry.

A better perspective of the present status of the East Texas field can be had by reviewing its history.[1] The field is roughly 120,000 acres in extent. To date approximately 10,160 oil wells have been completed; eventually, it is estimated that the total producing wells will number at least 15,000.

Although the average well spacing in the field at present is 11 acres to the well, there are numerous small tracts in the field of three acres or less on which wells are drilled. It was not until some time after the development of the field had been started that any orders were issued limiting the minimum spacing. The first order issued by the Railroad Commission limited the minimum well spacing to 20 acres. Because of offsetting difficulties that arose, this order was never rigidly adhered to and on January 31, 1933, the order was revised, reducing the minimum spacing on offset wells to about 10 acres per well. The reason given for the change was that an increase in ultimate recovery would result.

Regulation of production in the East Texas field has always been conspicuous because of its absence. From the time the Railroad Commission issued its first order setting a daily maximum allowable production for the field, one restraining order after another has been obtained in court by operators. Recently, however, a valid order has been written that has thus far withstood one attack in court. This is the order made effective April 14, 1933, and is the basis of the proration order in force in the field at this time. Under this order 15 per cent (now reduced to 10 per cent) of the hourly potential flow of the field is the daily allowance. With the number of wells producing when the order was issued, this gave the field a maximum daily allowance of about 750,000 barrels. From April 24 to June 13, the period during which this order was in force, the field produced at an average rate of close to 1,000,000 bbl. daily. This flood of oil brought on a crisis. The price of oil dropped to levels far below the cost of production. About the end of May, 1933, signs of depletion in reservoir energy began to appear. Many wells ceased to flow.

On June 12, 1933, at a hearing held by the Commission in Austin, operators in the field were almost unanimous in requesting a reduction in the field allowable. Accordingly, at midnight, June 13, a new order went into effect, reducing the maximum daily average withdrawal from the field. Under this new order the daily allowance, computed on the same basis as the previous order, was changed from 15 per cent to 10 per cent of the hourly potential flow. This was a reduction of one-third, or, based on the present capacity of the wells in the field, a reduction from 850,000 bbl. to 550,000 bbl. a day.

Some of the difficulties that have arisen in enforcing curtailment are of interest. Before proration went into effect in August, 1931, the daily production, which was increasing rapidly day by day, had reached 800,000 barrels. Curtailment in some form became imperative and the State Railroad Commission took over the regulation of production in the field. So far as the Commission was concerned, the necessity for curtailment was principally to prevent physical waste, waste such as might result from too high a rate of production that would cause dissipation of gas energy or hasten water encroachment. The first order issued set a maximum daily allowable production of 325,000 barrels. This figure was based chiefly on evidence submitted by engineers and operators in the field indicating that any greater rate of production would result in serious water encroachment, a condition that eventually would result in a decrease in ultimate recovery. Under this first order, all wells in the field—there were less than 2000 then—were each given a straight allowance of 225 bbl. a day. As new wells came in the allowance per well was reduced until on August 1, 1932, it was only

[1] *The Petroleum Engineer*, September, 1932, p. 73.

43 bbl. a day. On September 1, 1932, the maximum daily allowable for the field was increased to 375,000 barrels.

Although these orders were issued there was no effective enforcement. Much oil was being produced above the allowable and the running of "hot" oil became a racket. On October 15, 1932, another order was put into effect, reducing the daily maximum allowable to 335,000 barrels. On December 8, 1932, the field was further curtailed to 310,000 bbl. daily.

It was early recognized that the State statutes were inadequate for the effective enforcement of proration regulations. A market demand law was subsequently passed by the

Status of East Texas Field

State Legislature. This allowed the Commission some latitude in curtailing the fields in the State to market demand requirements, something they had not been able to do up to that time. On December 10, 1932, a new order went into effect, the basis of which was known as the Buck plan. Under this plan the maximum production for the field was set at 325,000 bbl., of which two-thirds was allocated on a per well basis and the remaining one-third on the bottom-hole pressure and acreage. Strenuous opposition was voiced against this order chiefly on account of the inclusion of acreage so at noon, December 17th, the field was shut down for two weeks in order that bottom-hole pressures and other subsurface data could be collected and used in preparing a new proration order. On January 1, 1933, the field was again opened up and a temporary order issued, setting the daily maximum allowable for the field at 290,000 barrels.

At this juncture dissatisfaction was rampant among operators regarding proration regulations in the field. This resulted in a new order being issued on January 10, 1933, allocating to each well 26 bbl. daily, plus 2 bbl. additional for a bottom-hole pressure up to 1000 lb. and 0.6 of a barrel for each 100 lb. of pressure above 1000 lb. to a maximum of 31 bbl. daily. Under this order, to be in force until April 1, the total production from the field was not to exceed 290,000 bbl. daily. Revisions in the well allowances were to be made on February 1 and March 1 in order to take care of wells completed during the month.

Another order, effective March 19, and to be in effect until June 1, 1933, was issued by the Commission permitting a daily maximum allowable production from the field of 400,000 barrels. The issuance of this order was prompted by an investigation of the existing conditions, which showed that although the field was only allowed to produce a maximum of 290,000 bbl. daily actually more than 400,000 bbl. was being produced. By raising the allowance for the field to 400,000 bbl. daily it was thought perhaps things would right themselves.

Before a three-judge federal court at Houston on January 26, 1933, evidence was heard in a suit attacking the Railroad Commission's order then in force of 290,000 bbl. because it was on a per well basis. After several weeks the court returned a decision, holding that the order was not valid, that it was confiscatory and that it stripped the best properties down to the level of the worst and took from one owner to give to another. In effect the decision threatened the Railroad Commission with contempt of court should it again fail to write a valid order. Difficulties also arose over the operation of the marginal well law. The State Attorney General advised the Commission that it could not reduce the per well allowance in any well to below 40 bbl., the minimum for marginal wells in the East Texas field. A State marginal well law was subsequently passed, reducing the marginal well allowance for the East Texas field to 20 bbl. per well. On April 6, 1933, the field was again shut in, this time for the purpose of making potential flow tests. The field was to be shut in for five days to allow the pressure in the reservoir to equalize, and to give operators an opportunity to make necessary modifications on well connections for making potential flow tests. Starting on April 11, two-hour potential flow tests were made on 283 wells equally distributed over the field. In making tests only 50 or 60 wells were opened at a time. The results obtained gave the field a daily potentional flow of 126,000,000 barrels. The field was opened up again on April 24, 1933, and a new order issued, the daily maximum oil allowance in which was 15 per cent of the hourly potential flow shown by the tests. This set the maximum allowable production for the field at about 750,000 bbl. per day. For the seven-week period from April 24 to June 13, the time this order was in effect, an average of approximately 1,000,000 bbl. per day was produced. As was stated at the beginning of this article, this flood of oil had serious consequences. The high rate of withdrawal had brought a large number of wells in the field to the pumping stage.

To date the field is estimated to have produced in excess of 320,000,000 barrels. The original reservoir pressure was 1620 lb. per sq. inch. On June 8, 1933, the average bottom-hole pressure was 1240 pounds. At this writing the estimated reservoir pressure is less than 1200 lb. per sq. inch. On the basis of these figures this gives an average drop of .84 lb. per million bbl. produced during the life of the field to date. Of the total 320,000,000 or more bbl. produced, not more than 100,000,000 is estimated to have been recovered at a rate of 800,000 bbl. a day or greater, the remainder being produced at a much lower average rate, probably not greater than 300,000 or 400,000 bbl. daily. In considering these figures it must not be forgotten that the field has been shut in at intervals, the total time of shutdown being about six weeks. With the present production rate, which averages about 800,000 bbl. daily, 2½ lb. per million bbl. is the estimated pressure drop.

The average reservoir temperature, which was 152 deg. fahr., is now about 145 deg. fahr. according to latest estimates.

The number of wells showing water in the field is estimated now at 500, although the total amount of water produced with the oil probably does not exceed 10,000 bbl. daily. Investigation in the field discloses that the rate of water encroachment is relatively slow compared with some of the early estimates. It is asserted that the water table to date has risen 4½ ft. to 5 ft. on the average throughout the field. It is quite likely that water coning has appeared in certain wells in the field where the rate of withdrawal of oil has been excessive and the damage done at high rates of withdrawal still remains to be determined. At a rate of withdrawal of between 400,000 and 500,000 bbl. daily it is asserted by many engineers and operators that water encroachment can be kept under reasonable control.

Differences in permeability is one of the most important factors accounting for the variation in the flowing capacities of the wells in the field. In the southeast corner of the field the producing sand is known to be of low permeability. In the central and northern part of the field the producing sand is more permeable. To what degree permeability will affect ultimate recovery is still in doubt.

In later articles to appear on the East Texas field the underground conditions of the field will be discussed in fuller detail.

Concrete substructure on a well in the East Texas field standardized for pumping

By
DEWEY T. ROSS
Construction Engineer

Construction and Installation Problems

INSTALLATION of surface pumping machinery on hundreds of wells in the East Texas field is now actively in progress. A sudden demand for large quantities of pumping equipment came during the month of May when infallible signs observed in the behavior of many wells indicated that they are fast approaching the end of their natural flowing life. If this demand shows no signs of abating it is evident that a formidable amount of construction work, involving the installation of this well pumping machinery confronts operators in the East Texas field. In a field of such extent the surface conditions affecting the installation of equipment vary quite widely. Therefore, a brief presentation of some of the construction and installation problems involved is of pertinent interest.

During the last few weeks several hundred wells have been equipped for pumping and many more are in the course of being equipped and will be ready to be produced by pumping within a few hours' notice when the occasion demands. Most of the surface pumping equipment being installed is of the latest design and of a uniformly high grade. Its proper installation, therefore, is an important essential that affects the standard of performance and the amount and economy of service that will be obtained from the equipment during the years it is in operation.

All surface machinery being installed is laid on concrete foundations where these are necessary. This applies both to individual pumping units and to central powers. Foundations should be proportioned with due regard to the local conditions for there is a wide variety of soil conditions found in the field. In the low-lying swampy areas and in the river bottoms the top of the foundations should be above the high water levels of the heaviest rainy season. Poor soil conditions in these areas also require that the footings be ample to prevent settling and consequent misalignment of the equipment. If the foundation is laid on made-up ground the latter is, where it is possible to do so, thoroughly wetted down with water and allowed to settle before the concrete is laid. In many cases this precaution is not taken either because of the expense involved or the time necessary. Safe bearings that will apply to soil conditions in the East Texas field will range from 1000 lb. to 4000 lb. per sq. foot. Only where soil is exceptionally hard and firm should it exceed this amount. Foundations in the river bed area in East Texas are usually made shallow and broad so that a low bearing pressure is obtained. In most places there it is also found that the upper soil is more firm than that underneath, and for this reason, foundations should not be too deep. In the higher parts of the field it is usually necessary to remove the overburden to get down to solid ground.

As a selection of the site for central powers is governed by the location of the wells and the general topography, the soil conditions must be accepted as a matter of course, and the construction foreman has to use his own judgment in regard to foundations. On many sites in the field excavation is usually necessary. If a power and site is on a hillside, excavation can be made by means of surface scrapers and mule teams. Where the surface is fairly level excavation is usually done by hand. When the site for a central power has been staked out, usually before placing the concrete blocks for the power, stakes from the center of the power to the wells are driven to expedite the work. After the foundation pit has been excavated in accordance with the required dimensions and the form set a template of the bolt circle in the base of the power is made and in it the anchor bolts are suspended in the exact position they will occupy in the completed job. The concrete block is then poured to within several inches of the top of the anchor bolts. Not until the concrete has been allowed to set properly is the template removed and the power carefully

lowered over the bolts into a position on the block where the anchor bolts protrude just enough to allow the nuts to be started on the bolts. In this position the power is set on blocks, after which cement grout is run under the power. Before the cement grout is thoroughly set the blocks are removed and the power is pulled down on the anchor bolts to its final level. Leveling of the power is best done by instruments and is an operation in which the greatest care should be exercised. After the power is securely set on its block the whole base may then be grouted in and all the necessary drains and trenches finished. Precaution is usually taken to install drain pipe in order to carry off the drainage around the power if this be found necessary. Drains should be made easily accessible for cleaning.

Many companies are now following the practice of putting in concrete floors on jack pumping wells. Some have small concrete cellars for the casinghead connections. If the wells are situated in the bed of a creek in loose ground — as many are in the field — the floor is sometimes reinforced to prevent damage from settling. Concrete foundations for geared powers take from 21 to 40 cu. yd. of concrete, the amount depending on the soil conditions, the size of the unit and the requirements of the company. For jack-pumping wells the amount of concrete required varies from 5 cu. yd. on small wells to 10 cu. yd. for more elaborate settings, but the average jack setting takes about 5 cu. yd. of concrete. About fifty geared powers have already been installed in the field and the eccentrics or cranks on a number of these are set close to the ground. The 30- or 40-ft. length of shaft is laid in a concrete trench as is also the power itself. A substantial wall about 2 ft. thick forms the side of the trench and the wall of the power pit.

On wells equipped with individual pumping units and steel rig fronts the practice of installing foundations varies according to the whims of the engineers or the construction parties in charge of the work. It is good practice to tie in the sampson-post and jack-post foundations. When concrete walls are laid these should not be bonded to the main foundations for settling or other surface movement will lead to cracking.

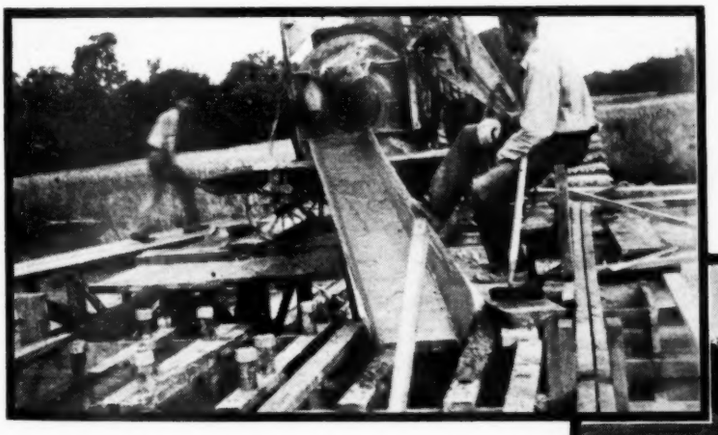
On wells that are standardized or are equipped with individual pumping units, the sizes of foundations and the amounts of concrete used vary from 20 to 50 or 60 cu. yd., depending on the installation and the prevailing practice of the company.

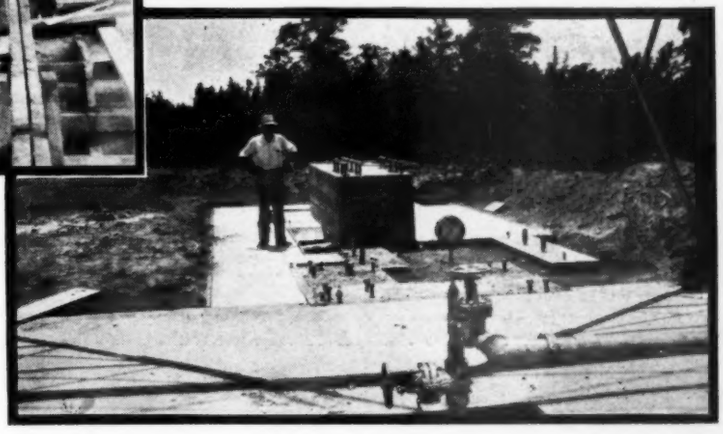
Much more attention than formerly is being paid to installing surface equipment at wells and many companies have special construction gangs who do nothing else but this work. Others again turn the job over to a contractor on a turnkey basis. One major company in the field has a standard setup for its pumping wells. A standard set of blueprints show all the dimensions of the foundations and the engine and belt house. One feature of this standard setup is the limited number of control points, the belt centers, by means of which the tolerances in the field are held to within an eighth of an inch, thus assuring proper alignment of the equipment. The footings of the sampson-post are flared out at the base so that a large bearing surface is obtained. Further strength is gained by tying in the sampson-post and jack-post foundations at the base. The jack posts are of concrete and the sampson posts of steel. The engine and belt house is of corrugated sheeting on a wooden frame, the latter being specially designed with heavy bracing for oil field service. An interesting detail is the concrete derrick floor in which there are provisions made for getting into the casinghead fittings. Another provision is a small concrete sump, the capacity of which is sufficient to hold the total tubing drainage when wells are being pulled.

In many parts of the field the topography is such that the installation of powers offers interesting problems. In one power recently installed the layout of pull-rod equipment necessitated a road crossing seven ft. deep. In such cases recourse is had to the use of holdups and holddowns. On this power, which is one of the heaviest in the field, having 14 wells on it, concrete is used throughout, both at the wells and at the power.

Aggregate for the concrete is obtained locally. Up to the present it has been the general practice to mix concrete on the job by means of portable mixers. It is reported that transmix concrete, supplied from plants located at advantageous points in the field, will be available in the near future. A company has recently been organized at Longview to give this service and is reported to be about ready for active operation. Concrete mixed in transit and all ready to pour when it arrives at the job will be available for delivery by truck to any part of the field. There are some parts of the field that even during the dry season of the year are difficult or impossible to reach by truck, where it will still be necessary to use concrete mixed on the job. Shipping in of heavy equipment to such locations is usually done by mule team.

Climate is one factor that must be reckoned with in the East Texas field. Installation of equipment during the summer months when the rainfall is slight is vastly more easy and less costly than during the season of heavy rainfall. Indeed, many of the wells cannot be reached during the winter months when roads are under water or are impassable, which is one reason for the intense activity in installing equipment at this time.





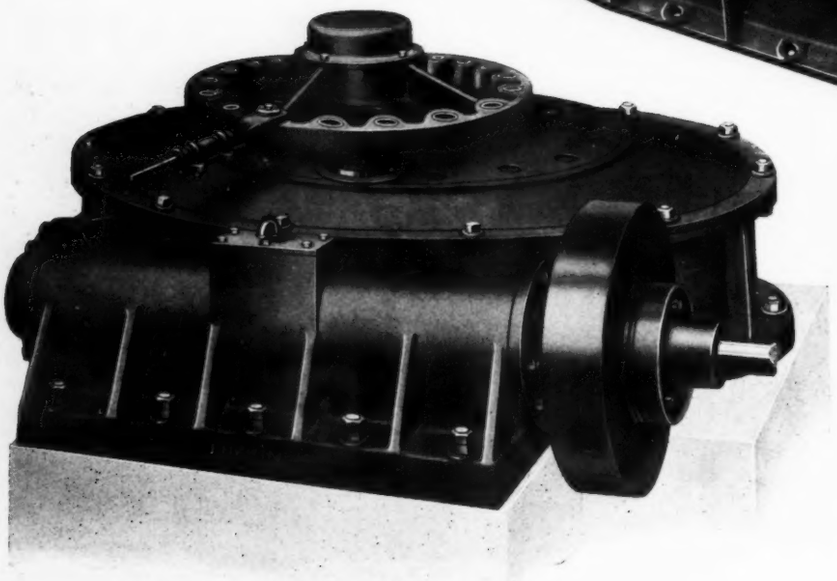
Above — Concrete foundations being poured for pumping machinery at a well in the East Texas field

Right — Foundations laid and all ready to place machinery at East Texas well

UNITS WITH A BACK-

LUFKIN Central Powers

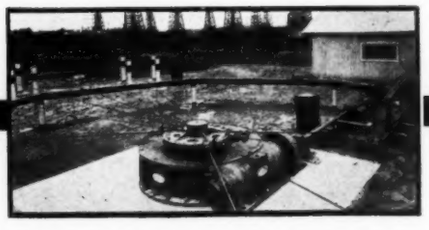
Lufkin Herringbone Central Pumping Powers



Lufkin Worm Gear Central Pumping Powers

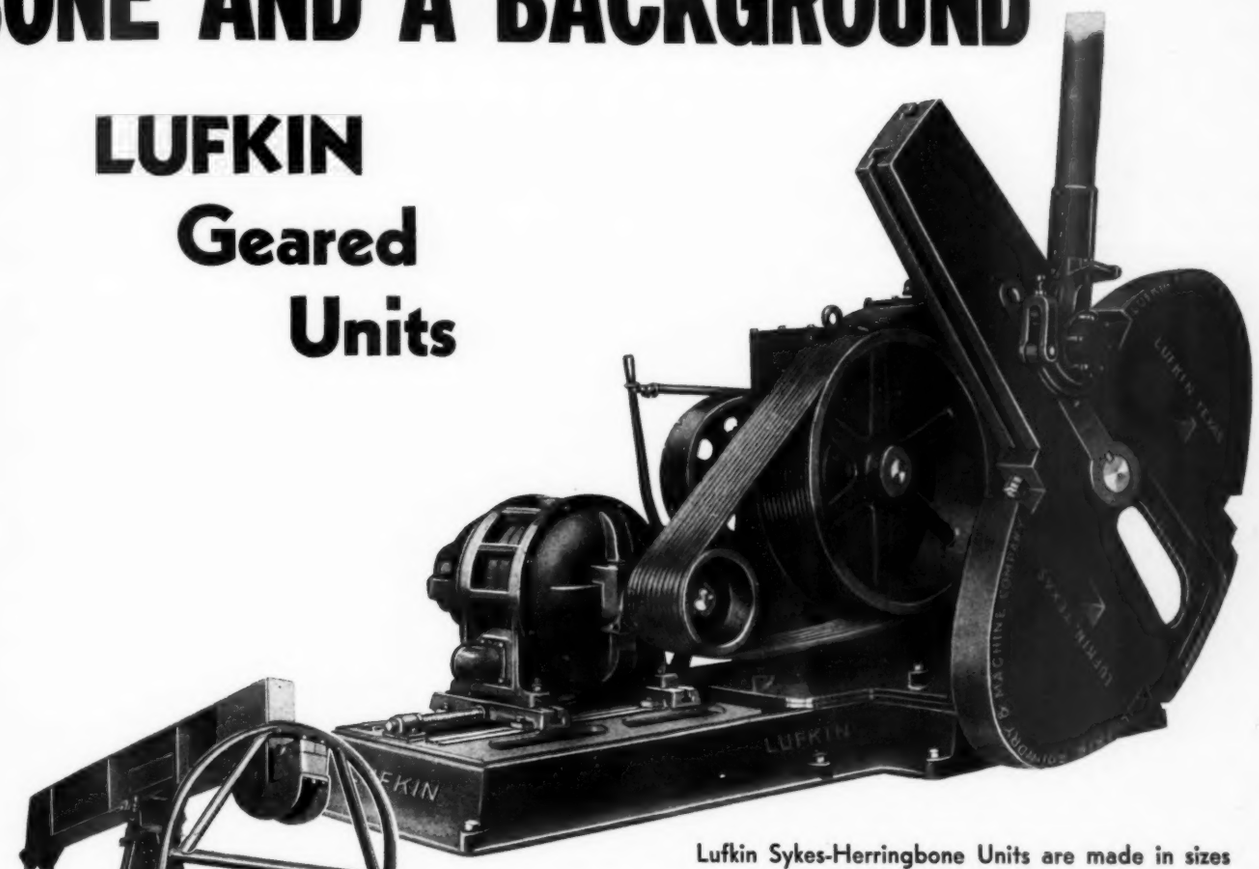
POWERS IN FOUR SIZES

Worm Gear
Herringbone Gear

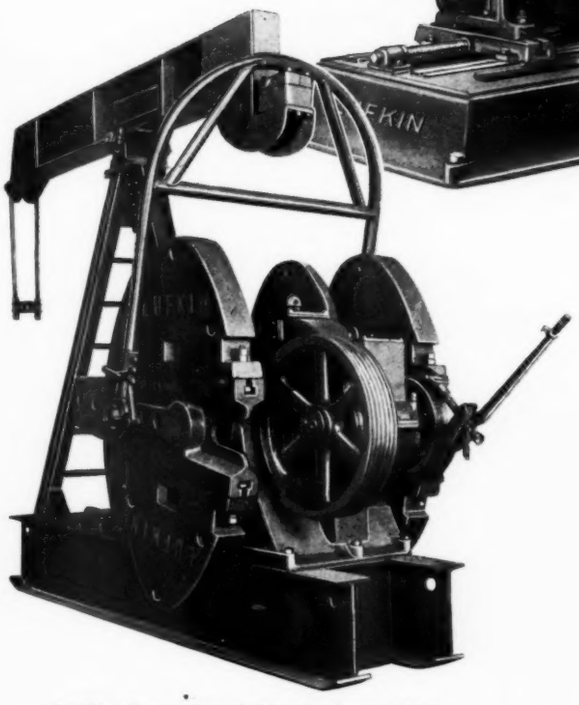


BONE AND A BACKGROUND

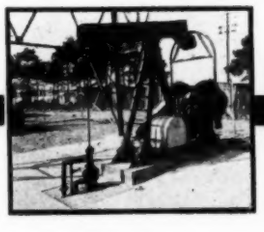
LUFKIN Geared Units

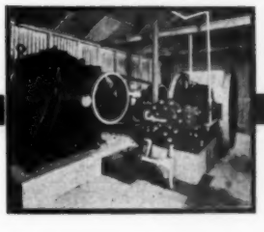


Lufkin Sykes-Herringbone Units are made in sizes to suit all field and operating conditions

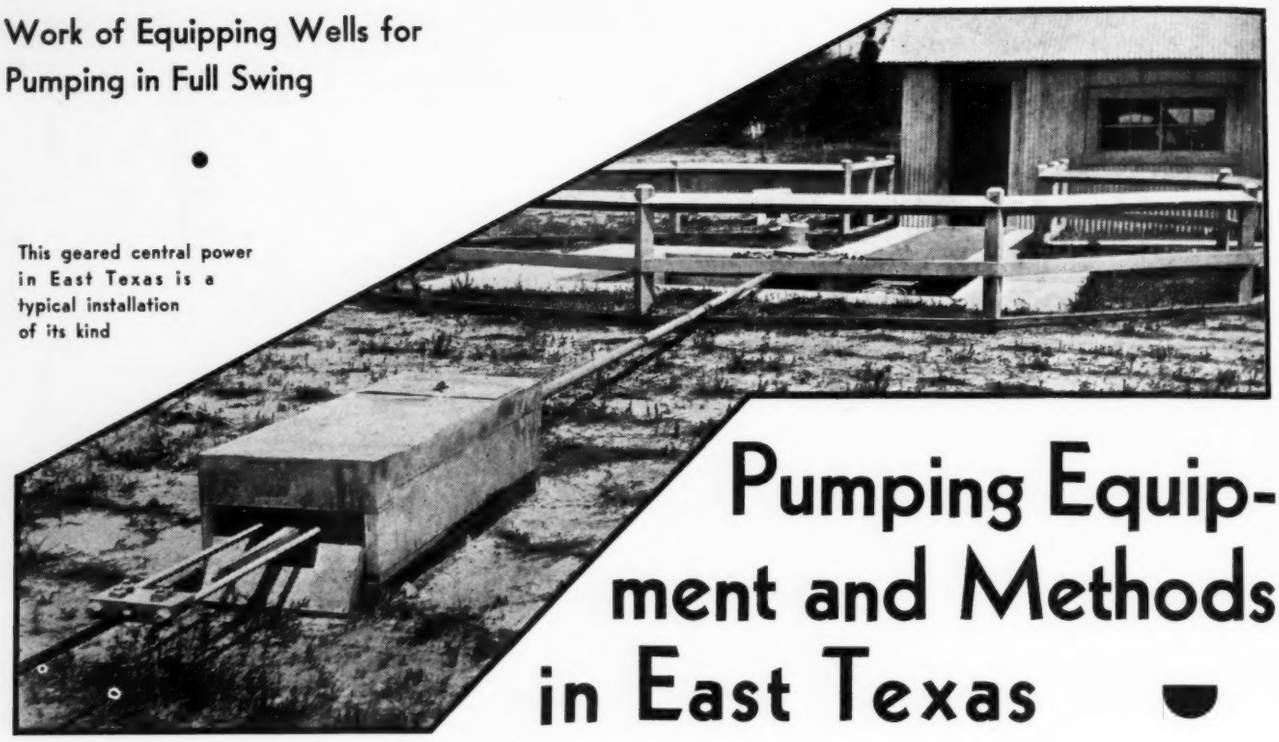


Lufkin Twin Crank Herringbone Unit Assembly





Work of Equipping Wells for Pumping in Full Swing



This geared central power in East Texas is a typical installation of its kind

Pumping Equipment and Methods in East Texas

By K. C. SCLATER

A SURVEY reveals that a variety of equipment has been or will be installed in the East Texas field and strengthens the belief that this field will develop into what has been predicted for it, a vast proving ground for improved pumping methods and equipment for lifting oil. During the last month the task of equipping wells for pumping began in earnest and a wholesome air of industrious activity now pervades the entire area.

Several of the pumping units and central powers installed in the field are the first installations of their kind, hence, with the large number of wells in the field eventually to be equipped, an excellent opportunity will be provided for observing and comparing the performance of these new units. This is one good reason why pumping operations in this field will be followed with interest.

The first central power in the field, a National bandwheel pumping power, was put into operation about two years ago and is installed on a lease of the Federated Oil Company in the Joiner area. A Lufkin geared power was installed in the same area some time later on a lease of the Hunt Production Company. These were followed by other installations and by about the beginning of May of this year some 20 central powers in all had been installed. During May and up to June 15 it is reported that orders for about 70 more powers had been placed, a number for immediate and others for future delivery. Some of these have been installed during the past month.

A description and specifications on the details of some of these new geared powers will be of interest.

The Imperial No. 80 Oil Well geared power manufactured by the Oil Well Supply Company, is of the overpull type and is driven through a double reduction gear. The power may be driven by gas engine or electric motor through a belt drive or direct-connected to a motor. The base and the spindle are cast in one piece, forming an oil-tight reservoir for the gear oil bath. A heavy cast-iron gear case cover totally encloses the gear compartment up to the main gear hub, for which it forms a babbitt-lined lateral thrust bearing. Two heavy bronze bushings on the spindle carry the lateral rods of the eccentrics and main gear while the combined vertical loads of these parts are carried by a large-capacity ball bearing that seats in the base around the spindle. Timken tapered roller bearings support the pinion shaft and the intermediate shaft, the only two rotating shafts in the power. The main gear and the two eccentrics rotate about the spindle with their weight carried by a ball bearing and their lateral thrust taken by the bronze bushings on the spindle. The lower eccentric is keyed horizontally to the main gear and the upper eccentric in turn is keyed to the lower eccentric. Four heavy bolts hold these three pieces together so they rotate as a unit on the spindle. The eccentric straps of one-piece construction are unusually heavy so as to obviate the possibility of springing the eccentric in case a heavy load is concentrated at one point. These straps are babbitt-lined so the strap may be rebabbitted and used again in case of excessive wear. This construction eliminates wear on the eccentric proper. The clevis holes have replaceable hardened steel bushings so the whole strap need not be scrapped when the clevis pins eventually cause wear. Cast-iron covers over the eccentric-strap bearing surface and over the gear-hub bearing surface protect these oil surfaces from dust, dirt and water. Combination steel clevices and pull-rod clamps are provided to attach the pull-rods to the power. The clevis pins are drilled for lubrication by periodic oiling of candle wicking, which the manufacturers recommend to be installed in the oil holes. All gears and some of the anti-friction bearings run in an oil bath in the gear case, the capacity of which is 35 gallons. Those bearings above the oil bath are fed by individual positive force feed oil lines from a mechanical lubricator driven from the pinion shaft. The oil from the force-feed bearings drains by gravity back into the gear case, from which a return line leads to the force-feed lubricator under a positive head of oil at all times to insure an unfailing supply of lubricant. This combination of oil bath and force-feed lubrication insures adequate and positive lubrication to all moving parts of the power.

This unit has a normal rating of 80 hp. at 20 r.p.m. of the eccentrics and a maximum rating of 115 hp. at 30 r.p.m. of

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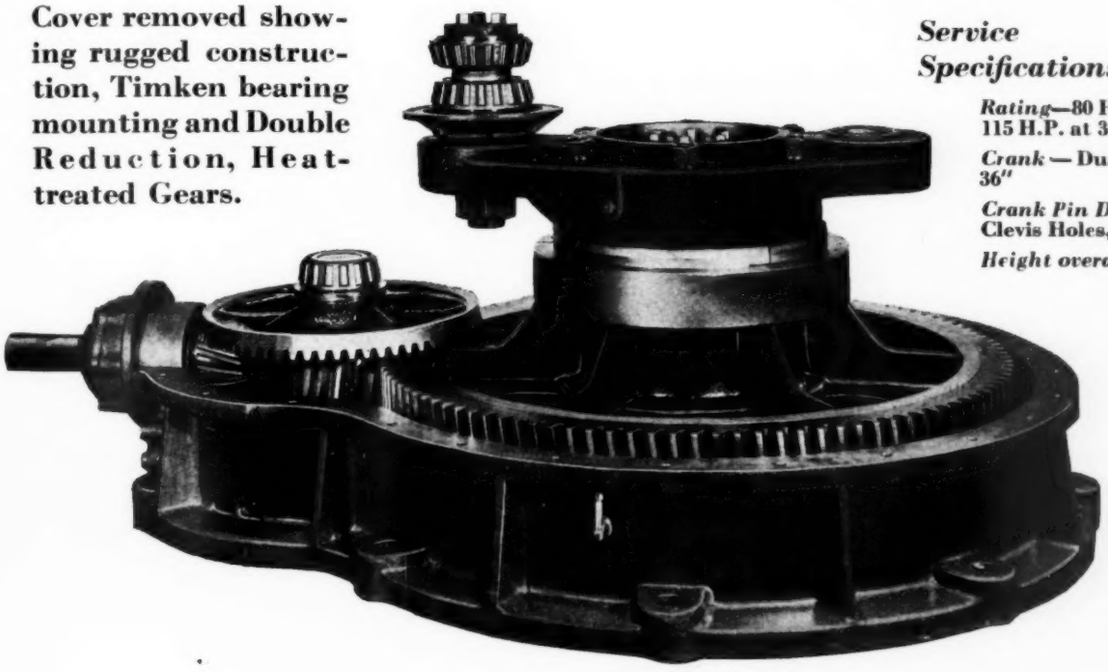
[Companion to the popular Imperial No. 80 Eccentric Type Oilbath Geared Powers]

Cover removed showing rugged construction, Timken bearing mounting and Double Reduction, Heat-treated Gears.



Service Specifications

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Crank — Dual Stroke, 30 and 36"

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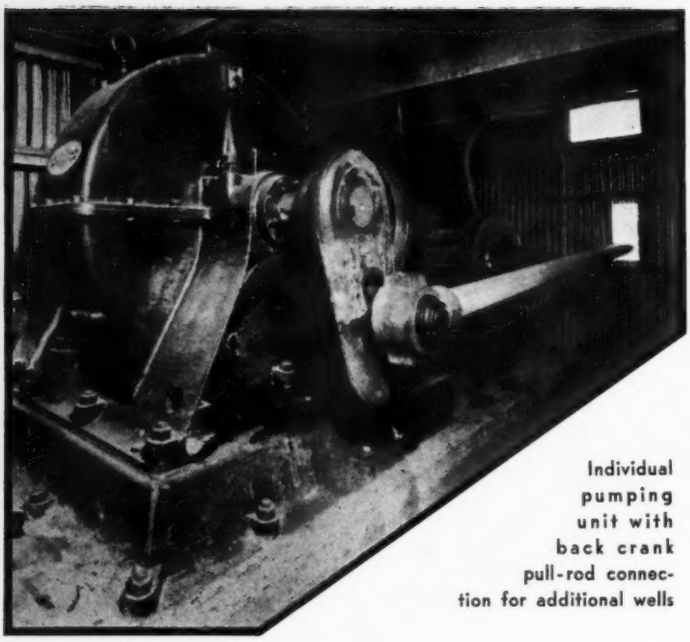
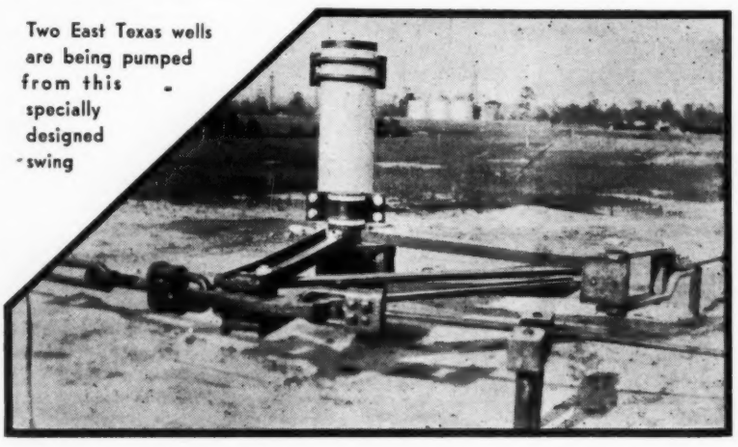


Individual pumping unit with back crank pull-rod connection for additional wells

the eccentrics. The ratio of reduction is 27.7 to 1 by double reduction. The high-speed pinion is 14-tooth, 2½ diametral pitch, 4-in. face, spiral bevel, of heat-treated chrome nickel steel, integral with the shaft. The intermediate gears are: 64-tooth, 2½ diametral pitch, 4-in. face, spiral bevel gear, of double heat-treated cast steel, and 18-tooth, 2 diametral pitch, 6¼-in. face, helical pinion, of heat-treated forged steel. The low-speed gear is 109-tooth, 2 diametral pitch, 6-in. face, helical gear, of double heat-treated forged steel rim, shrunk on to cast-iron hub and keyed in place. The high-speed shaft is 4 in. in diameter of heat-treated chrome-nickel steel, while the high-speed extension is 3½ in. in diameter by 8 in. long and has a ⅜-in. by 1-in. by 4½-in. keyway. The intermediate shaft is 4¼ in. in diameter and is of SAE 1035 steel. The high-speed bearing has a Timken tapered roller, the intermediate bearing a Timken tapered roller and the low-speed thrust bearing a ball bearing with 1⅜-in. balls on 19¼-in. diameter circle. The low-speed gear hub bearing has bronze bushings 15 in. in diameter by 13½ in. long. The overall length of power from end of pinion shaft to opposite end of base is 99 in., the width of base 68 in. and the height overall 60 inches. The height above ground line of the center of high-speed shaft is 12¾ in., of the lower eccentric 29¼ in., and of the upper eccentric center 38¾ inches. The total weight with 24-in. eccentrics is 17,400 lb., with 30-in. eccentrics 18,500 lb., and with 36-in. eccentrics 20,000 pounds. The maximum safe well loads that may be attached to the power and concentrated at one point on either eccentric are as follows: On 24-in. eccentric 17,800 lb., on 30-in. eccentric 14,300 lb., and on 36-in. eccentric 11,800 pounds. Based on a combined overall efficiency from power to pump of 60 per cent, the b.hp. input of power varies from 40 b.hp. at 10 r.p.m. to 95 b.hp. at slightly more than 23½ r.p.m.

Another type of power similar to the foregoing being installed in the field is a crank-equipped heavy-duty unit known as the Imperial No. 80-SC oil bath geared power, the rated hp. input capacity of which is the same as for the power just described at 20 r.p.m. This unit has a sturdy cast-steel crank, by which either a 30-in. or 36-in. stroke may be obtained, in place of the two eccentrics provided on the No. 80 unit. The rugged semi-steel base with integral spindle is very similar to the base of the No. 80 power, the chief difference being in the use of the large heavy-duty Timken roller bearings in place of the bronze sleeves used on the spindle of No. 80. The same size and type of gears, high and intermediate speed shafts and shaft bearings are used on both powers. The weight of this unit is 11,500 pounds.

Another interesting new geared power in the field is the Emsco-Falk 36-in.-stroke geared power, which is of the crank disk overpull type. The grey-iron housing has a heavy metal section and unusually heavy ribs both in the upper and lower halves. The first train of gears is of the spiral bevel type, giving the required right-angle turn characteristic of the bevel gear. The second train of gears is purely helical. Suitable radial and thrust resisting roller bearings are used throughout. The high-speed pinion is rigidly supported by a Norma Hoffman precision type straight roller bearing for radial load at the inner end and by a double Timken bearing (unit type non-adjustable) at the outer end to carry the thrust load. The low-speed pinion shaft, on which is mounted the high-speed gear, is also supported at one end by a Norma Hoffman floating type roller bearing to carry the radial load and at the upper end by an exceptionally heavy double Timken fixed bearing (unit type) to carry both the thrust load of the gear and the heavy radial loads of both gear and overhung crank. The crank disk is mounted on a similar double Timken bearing (unit type), totally enclosed. The crank pin is a steel forging shrunk into a heavy boss on the crank and there are no keys to weaken this section. The crank disk is made of cast steel, designed for maximum strength, and the holes for pull-rod connections have hardened steel bushings. The lubrication of this unit is complete, thorough and automatic. A large volume of oil, 70 gallons, is stored in the bottom of the case. A special reversing Perfection oil pump with bypass valve is mounted on the cover and is driven through a set of speed-increasing gears from the intermediate shaft, providing a sufficient volume of oil even when the wells are pumped at a speed of only six s.p.m., yet producing no excessive pressure should the well be pumped at 30 strokes per minute. Each gear is lubricated by direct spray and each bearing by a flood of oil. Each bearing is sealed against leakage of lubricant and against admission of dust or dirt to the inside. The two intermediate bearings and the lower-speed bearing are sealed by solid caps. The whole unit is accessible. The industrial rating of this power at 20 r.p.m. is from 160 hp. to 200 hp. although the oil field rating of 100 hp. is given at this speed. The first of these units to be installed in the field is driven by a twin-cylinder 150-hp. Bessemer gas engine, a 40-ft. line shaft, running on self-aligning Timken bearing pillar blocks with wedge adjustable sole plates, being used between the prime mover and power. A Fairbanks-Morse Flex-Mor V-belt is used for



Two East Texas wells are being pumped from this specially designed swing

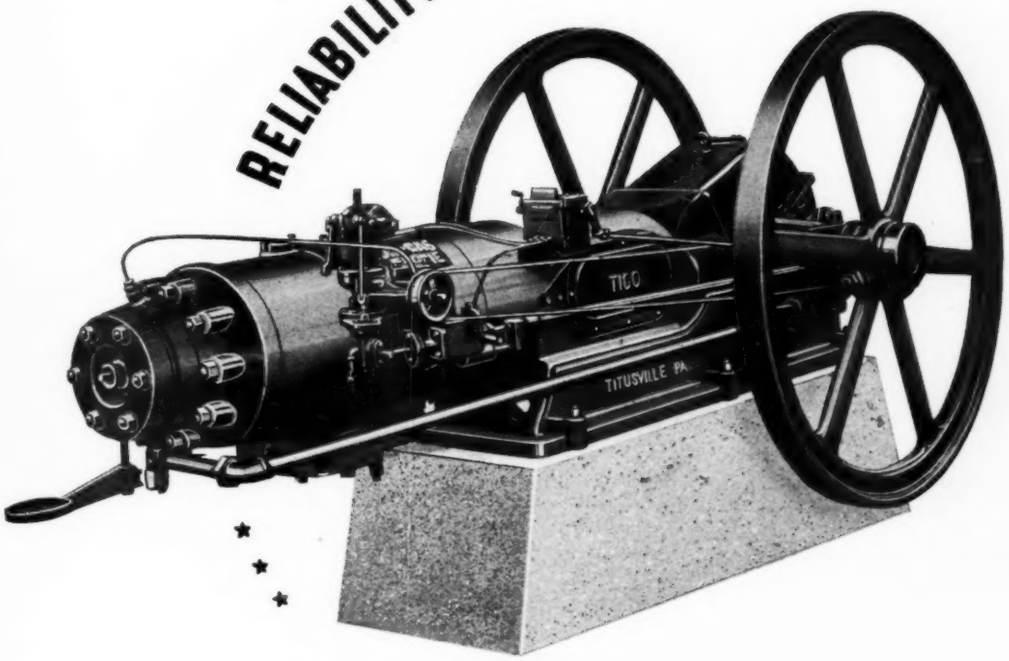
SIMPLICITY

RELIABILITY

ACCESSIBILITY

ECONOMY

FLEXIBILITY



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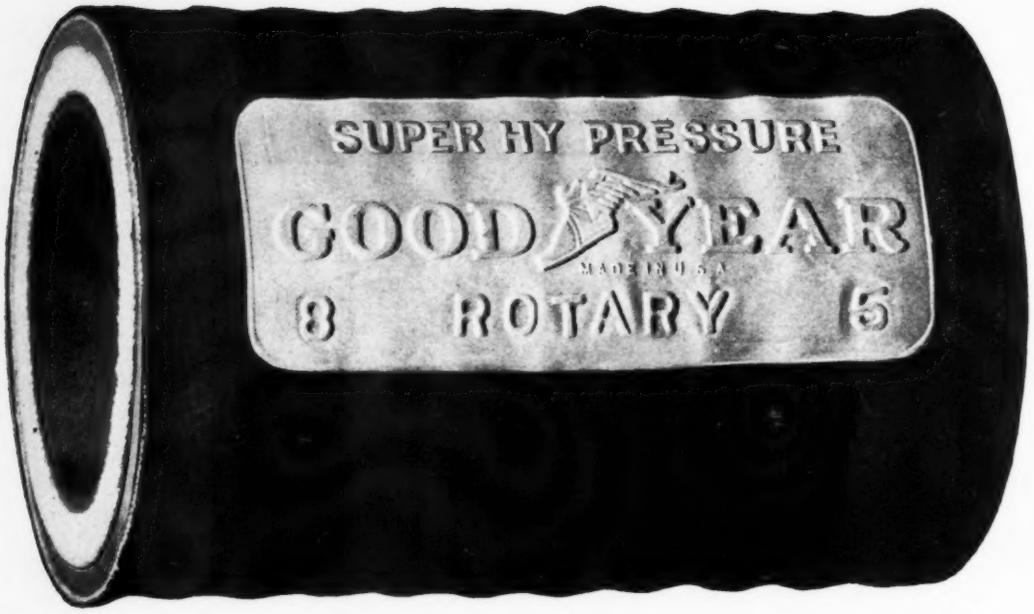

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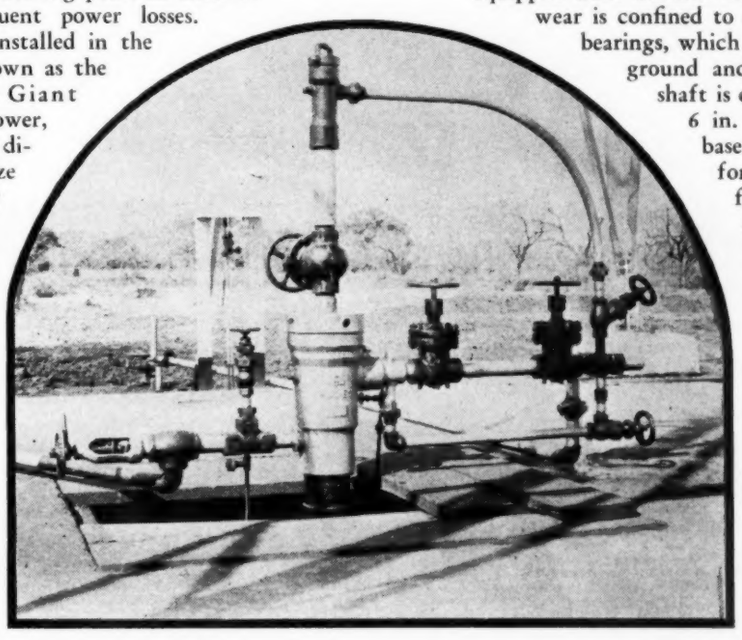
the drive from the engine to the line shaft. A Timken bearing V-belt clutch sheave is mounted on the power line shaft and a solid V-belt-driven sheave is keyed to a jack shaft that runs on two bearings, and is connected to the engine shaft through a Falk flexible coupling. A heavy Timken bearing grooved idler working upward on the inside of the bearings is mounted on steel framework.

Another of the geared pumping powers of new design, many of which are being installed in the field, is known as the type G-100, manufactured by the National Supply Company. This power is of the double-crank overpull type and its construction is particularly suited to the geared design, as it permits using a rotating crankshaft mounted on widely spaced bearings. The double reduction gearing is entirely enclosed in a rigid housing, which protects it and permits thorough lubrication. The lower crank has a stroke of 36 in. and positions for 12 pull-rod connections, and the upper crank a stroke of 30 in. and positions for 8 pull-rod connections. The overall ratio of the double reduction gears is 20.9 to 1. The overall width of the housing is 69 in., the overall length 88 in., and the overall height of the power 62 inches. The gearing has been designed with wide-faced pinions of large diameter in order to obtain low bearing pressures. The first reduction is through a set of carburized alloy steel spiral bevel gears, and the second reduction is a set of wide-faced single helical gears. A comparatively low ratio has been selected in order to reduce the operating speeds and to give pinions of more durable proportions. The ratio of 20.9 to 1 gives a most satisfactory drive with either electric motors or gas engines. The power is supplied with Timken bearings throughout. A wide bearing spacing to handle the overhanging loads in the pinion shaft and the crankshaft is an especially noteworthy feature. In this power a distinct advancement has been made in the design of the pull-rod connections. The bearing is 3½ in. in diameter, operating in a bronze bushing and supplied with oil from a covered pocket. Lubrication of the power is provided by a simple pump enclosed in the housing and gear-driven from the main pinion. The lubricant is filtered by continuous circulation through an industrial Purolator. Circulation is indicated by a gauge located either on the manifold or in the engine house. An abundant supply of clean oil is supplied under pressure to every part of the enclosed transmission. The capacity is 20 gal. of oil, which is circulated through a filter at the rate of 8 gal. per min. and delivered under a pressure of from 10 to 20 pounds. Rolling contacts are provided in both sets of gears and at every bearing point in order to reduce wear and consequent power losses.

Lufkin geared powers installed in the field are of two sizes, known as the Standard power and the Giant power. In the Standard power, the worm gear is 52 in. in diameter and is the same size as used in the 6½-in. heavy duty worm gear individual pumping units of this manufacturer. This power is of the double-crank overpull type. The whole mechanism revolves on Timken bearings mounted on a steel column bracket securely fastened to the main housing casting and designed to withstand severe strains encountered in pumping. Arrangement is made for the slight adjustment to the Timken bearings by simply removing the cover on top of the crank. The worm shaft has a double Timken thrust bearing and Hyatt roller bearing on the flywheel end so the power may be run in either direction to suit the prime mover or may be reversed to obtain longer life in the wear of the gear. The crank is one solid steel casting securely bolted to the gear center with crank pin of ample diameter for strength and bearing surface. This power has a flywheel to insure steady operation and to aid in overcoming any reasonable out-of-balance condition so hard to eliminate in this class of service. This power may be coupled to any type of prime mover, electric motors, steam engines, single- or multi-cylinder gas engines. The crank has a 24-in. stroke and positions for 24 well connections. Gear ratios are 29 2/3 to 1 and 22¼ to 1 for motor or single-cylinder engine drives with V-belt or 44½ to 1 for direct-connected multi-cylinder engine drive. Holes in the crank disks have renewable bronze bushings. This unit is designed for loads of 40 to 50 horsepower.

The Lufkin Giant power has a worm gear 71 in. in diameter, with 6-in. face and $2\frac{7}{16}$-in. circular pitch, and the gear ratio 29 2/3 to 1, or 44½ to 1, that will handle loads of 250 hp. safely, although 100 to 125 hp. is its regular rating. The center trunnion of this power is 12 in. in diameter and of nickel chrome steel. Timken tapered rollers are used in the center bearing. The crank has a 36-in. stroke and the crank pin is 8 in. in diameter. Timken rollers are used in the crank-pin bearings, and the crank disk has holes for 20 well connections. The crank-pin bearings are automatically oiled by pump from the gear box while the gear bearings are oiled by pump from the base.

Several large Reid bandwheel powers are in course of installation in the field. These are known as the type PX, the largest and heaviest Reid powers made, and are designed to handle heavy wells where 100 hp. is the total power requirement. These powers are equipped with either 24-in. or 36-in. eccentrics. The bandwheel is 24 ft. in diameter, has a 28-in. face, and is built in six sections. Stiffening angles are electrically welded at the top and bottom on the inside of the rim to hold it rigid under the most severe driving strains. All permanent joints are electrically welded. Twelve driving angles, 24 upper spokes and 12 lower spokes, are used and their arrangement enables the power to be driven in either dirction without change. In this power the center shaft is equipped with Timken tapered roller bearings. All wear is confined to the inside surfaces of the bearings, which are made of Timken steel ground and hardened. The center shaft is of high carbon steel and is 6 in. in diameter. A cast-iron base, of ample proportions that form a substantial support for the rotating parts, is shrunk to the center shaft. In addition a sub-base is provided that is grouted into the concrete foundation and the fundation bolts run through it to the power base. This construction has the advantage that if it is necessary to move the power from the foundation it can be done without damage to the concrete by lifting the base off the sub-base, the latter being left in the con-



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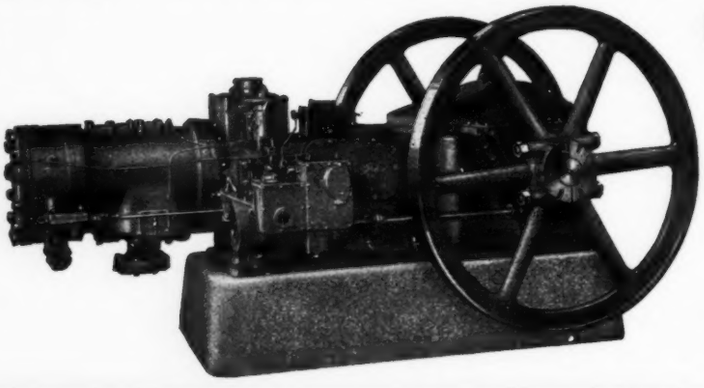

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Reid Band Wheel Powers and Gas Engines have been in continuous service for eighteen or more years on many properties, with minimum shutdowns for repairs, and are still operating satisfactorily. . . .

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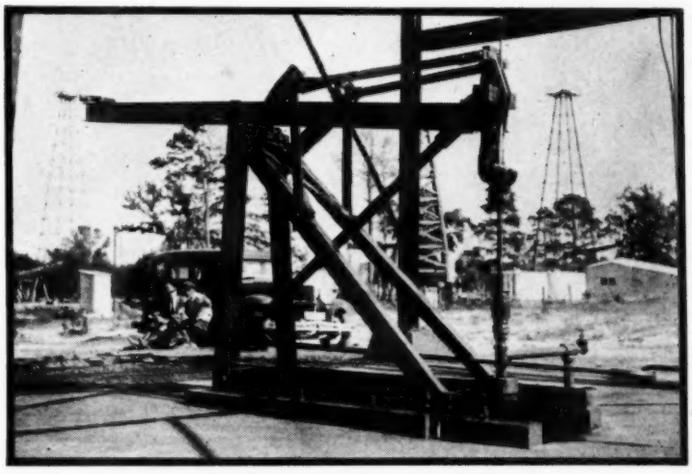
crete. A heavy semi-steel sleeve extends from the base of the power up through the wheel hub. The two eccentrics and the wheel hub fit directly over the sleeve, the entire assembly being held in place by two large binding bolts. This forms a very rigid construction and has the advantage that when used, only two bearings are required. One Timken bearing is placed at the bottom of the shaft and because of the Timken tapered construction is enabled to carry the weight of the moving parts and also the heavy loads from the belts and eccentrics. The other Timken bearing is placed at the top of the shaft and takes the radial and thrust loads at that point. The use of Timken bearings in conjunction with the sleeve mounting of the sleeve hub and eccentrics makes a rigid, perfectly aligned unit. The eccentrics are heavy castings with liberally proportioned bearing surfaces and are designed adequately to handle the loads that may be placed upon them. The eccentrics are also fitted with the Reid dust ledges, which exclude all dirt and sand from the lubricating oil and between the bearing surfaces. The drive from the wheel hub to the upper eccentric and from the upper to the lower eccentric is by means of the Reid patented wedge locking device, an arrangement that has been successfully used in other Reid powers and gives at all times a positive drive easily adjusted and without the use of babbitt or wooden blocks. Attached to the power base is an oil reservoir with a capacity of 24 quarts. The oil circulating pump is built into the reservoir and is operated through a lever working on a cam attached to the lower eccentric. It has but two moving parts, the lever and the plunger, and requires no packing. The entire reservoir and pump assembly can be removed in less than five minutes' time, providing ease in cleaning. Clean oil from the reservoir is forced by the pump through a copper tube to the oil distributing manifold on top of the shaft. From the manifold three copper tubes lead the oil through regulating needle-valves to three separate sight glasses mounted on a bracket above the sleeve hub. From the glasses the oil is allowed to flow by gravity through copper tubes to a cast-aluminum eccentric and hub-oiling connection, so shaped that the oil is dropped into the wheel hub, thus distributing the oil through leads to the upper and lower eccentrics and into the wheel hub. After having passed through the eccentric hub bearing surfaces the oil flows down into the power base, where, together with the oil that has passed down the shaft it returns to the oil reservoir, is drawn through a screen and used again. A pressure relief valve is installed on the oil distributing manifold, relieving excess pressure in the system by returning a part of the oil directly to the wheel hub. A ¼-in. pipe filled with candle wicking is tapped into the oil recess of the lower eccentric and lubricates the pump cam ring. Beyond keeping the reservoir filled and making occasional adjustments of the feeds to the various bearing points, the lubricating system requires little or no attention. By the use of glasses sight-feed gauges and dust covers on the hub and eccentric, the oil is at all times completely enclosed. Accurate control of the quantity of oil flowing to the various bearing points is obtained by the regulating needle-valves, and makes it possible to regulate each feed according to the requirements. Should the oil pump or supply fail the oil remaining in the gauges will supply the necessary lubrication for a sufficient length of time to enable the operator to discover and remedy the trouble. This is an important feature that greatly lessens the chance of damage to the power due to failure to keep oil in a reservoir to the required level.

Pull-rod connections of ample strength to handle any wells that may be put on the power are provided. On this heavy bandwheel power two steel plates are bolted to the eccentric ring, one on the top and one on the bottom face of the ring, 1½-in. bolts with castellated nuts being used. A 2-in. steel pin passing from the top to the bottom plate holds two other steel plates that, being bolted together, form a clamp for the pull-rod. Idlers are provided with Timken bearings and are substantially constructed to withstand the strains that may be placed upon them. They have universal adjustments and serve to keep the belt tight at all times. The distance from the floor line to the wheel center line is 38⅝ in., to the upper eccentric 22⅞ in., and to the center of the lower eccentric 9⅞ inches. The belt tightener has a 24-in. by 28-in. pulley and a steel base of 6-in. I-beams. The total shipping weight for the bandwheel with 24-in. eccentrics is 18,000 lb., or with 36-in. eccentrics, 19,500 pounds.



One type of steel jack in use in East Texas

Pumping jacks and pull-rod equipment being installed are of the latest design and of steel construction. Pull-rods 1 in. and 7 in. in diameter are in general use. All pull-rod lines are carefully laid out and every precaution is taken to reduce friction and lost motion. Rod-line posts are cemented in and most are equipped with anti-friction devices. The steel jacks being put in are of modern design and mostly of the heavy type to cope with any severe pumping conditions that may ultimately be encountered in the field.

Individual pumping units on wells vary greatly in capacity and design. For the most part these are being installed in wells on the west edge and in the central and north central parts of the field where heavy pumping conditions are anticipated. Thus far the prime movers in the majority of wells being equipped for individual pumping have single-cylinder gas engines. There are, however, a number of multi-cylinder engines and electric motors being installed. It is estimated that of the 500 or more wells now equipped or being equipped with individual pumping units, about 100 have electric motors. A factor increasing their use is the introduction of triple-rated motors, whereby greater flexibility and a lower power cost is obtained.

Electric power is available to all parts of the East Texas field, and according to the attractive power schedules in force in the East Texas field it should be possible, with reasonable loads, to obtain a power rate of 1.2 cents per kw. hour. This rate, of course, will vary according to the load and may be less on large loads with a good load factor. An adequate system of gas supply lines also covers the field. These lines have been in use to supply drilling wells with gas and the system, which is operated by a gas company, is available to supply gas that may be needed at producing wells in the field. The gas rate is 22½ cents per 1000 cu. ft. for the first

200,000 cu. ft. and 11¾ cents per 1000 cu. ft. above 200,000 cu. feet.

An interesting trend in the field in equipping wells for pumping is the use of back cranks. This practice has come about because of the low daily well production allowed under proration regulations in the field. In these installations a pull-rod connection is attached to a back crank on the well, at which the prime mover is installed and from it one or two additional wells are pumped by jack. Another variation of this principle is the use of a pitman connection, the latter having been devised so that one or two additional wells may be pumped without the use of a back crank. This is a convenient and flexible arrangement, for during the period of light pumping the unit investment is spread over several wells and when the heavy pumping period is reached the jack installations can be replaced by large pumping units. Several of these installations are of interest and will be described in detail in articles to appear in subsequent issues of *The Petroleum Engineer*.

Individual gear-reduction pumping unit on an East Texas well

Quite a number of wells have been standardized for pumping and are equipped with steel rig fronts and counter-balanced units of various types. There are also many wells with the orthodox gas-engine drive through reversible clutch and bandwheel. Many of these are equipped with endless belts and idlers. The prime movers include all the standard makes of gas engines of the single-cylinder type.

Up to the present production in the field has been obtained chiefly by natural flow. In the pumping wells serious pumping problems have not yet been encountered. Paraffin trouble has been prevalent on both flowing wells and pumping wells, although on the flowing wells paraffin trouble is being successfully overcome by the use of chemicals, automatic scrapers and other devices; pumping wells, however, have not fared so well. Intelligent treatment with chemicals and heat will become more necessary as the reservoir pressure decreases. With the low daily rate of production and the relatively high reservoir pressure, at least so far as pumping wells are concerned, it is believed that the real pumping troubles in the field have not yet started.

In an effort looking toward low lifting costs when this period arrives, several methods of artificial lifting have been tried in the East Texas field. Among these that have attracted attention are the Hughes plunger lift, the Reda pump and the Gage pump. Many wells in the field have also had their flowing life prolonged by the use of flow packers on the tubing.

The Hughes plunger lift has been in successful operation in the field for several months in a well in the London district. A description of this pump and its principle of operation has been described in a previous article.[1] The Reda pump tried out is of recent and revolutionary design. It is a submersible electric-driven reciprocating duplex pump having a speed of from 100 to 200 s.p.m. In the test run in the East Texas field with this pump its average speed was 150 s.p.m. and length of stroke 3 inches. Plungers of 1⅛ in. in diameter were used and were driven by a 7½-hp. 410-volt Reda motor installed at 3600 ft. on 2½-in. tubing, using No. 5 three-conductor Reda cable for transmitting current from the surface switch to the motor in the well. The average daily results on a 29-day test with the pump operating on an average of 8¾ hr. a day were: 37.7 bbl. lifted; kw. per bbl. 4.686; kw. per bbl. per 1000 ft., 0.195; and average ampere load 5.90.

Tests made in the East Texas field with a Gage pump, which is hydraulically operated, were vitiated because of paraffin trouble and unfavorable conditions. Not until it is given a further test can its possibilities in the East Texas field be definitely known. One Sullivan pneumatic unit has recently been put into operation on a well in the south end of the field. This type of unit is in successful use in the Van field and in Oklahoma. A full description of this pump and its performance was given in a recent article.[2]

According to a recently published report by the U. S. Bureau of Mines on East Texas crude, the average gravity is 39.90 deg. A.P.I., the average sulphur content 0.25 per cent and the average viscosity 41 sec. Saybolt. As the gas dissolved in the oil in the reservoir begins coming out of solution at about 770 lb. pressure it is anticipated that some real pumping difficulties may be encountered after this reservoir pressure is reached. Up to the present the gas-oil ratio in the field has averaged 375 cu. ft. to the bbl., and has been remarkably uniform.

Most of the pulling and cleaning-out equipment in the field at present is of the portable type. Individual well-pulling equipment it is expected will also come into wide use later. Even now, many of the wells are provided with individual well-pulling equipment. More than 1000 wells in the field are being equipped with steel pumping derricks, 87-ft. and 94-ft. sizes, the trend being toward the 87-ft. size.

Facilities employed in the field to handle the oil at the surface from the wells to the lease storage tanks are of many different types. Usually two flow lines from the casing and two from the tubing to the well separator are installed on the well when it is brought in. It is quite likely that most operators will use only one lead line on the tubing to the tank battery when the well goes on the pump. It is the common practice with almost all operators when the well stops flowing to take up the large flow lines, if with these the well is equipped, and replace them with 2-in. or 2½-in. lead lines. While the wells are flowing it has been the practice for most of the operators to use an individual separator at each well. Now with the low daily production allowed and the prospect of many wells going on the pump, one or two separators are being placed at the tank batteries and through these all the wells on the lease will produce. Where two separators are used they are so connected with a manifold that individual well tests may be taken, or one separator may be used for a well or wells making water.

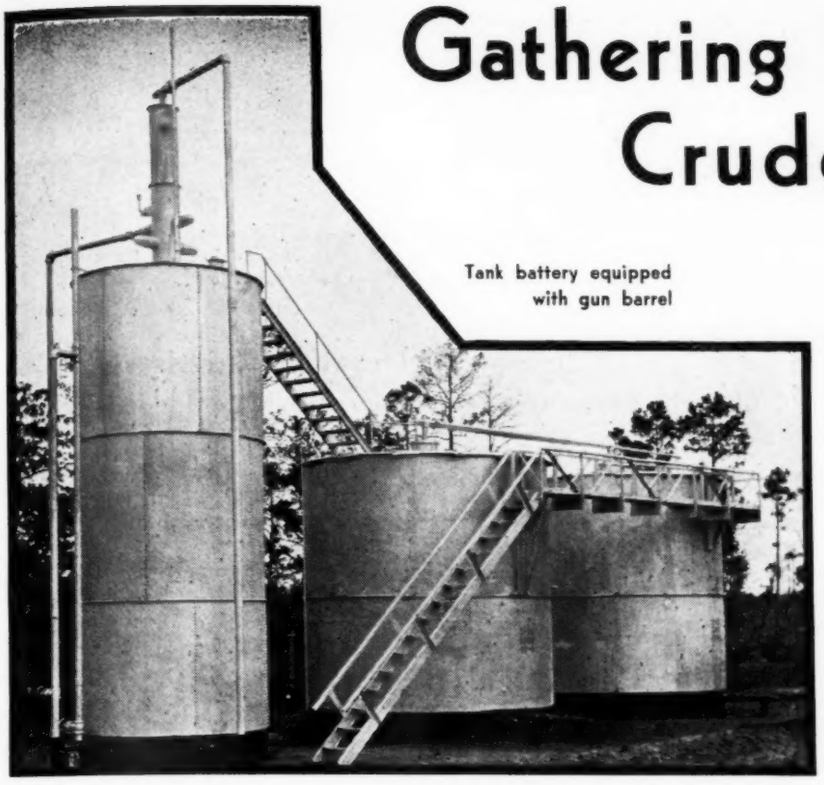
Water problems in the field have not yet become acute so that disposal of water is not troublesome. Surface evaporation in pits at the surface is sufficient to cope with the problem at the present time. Should the quantity of water increase, as it probably will, other means of water disposal will be required.

[1] *The Petroleum Engineer*, March, 1932, p. 108.

[2] *The Petroleum Engineer*, November, 1932, p. 32.

Gathering East Texas Crude Oil

By WARREN L. BAKER



Tank battery equipped with gun barrel

THE network of gathering lines serving the East Texas oil field is necessarily the most extensive system ever constructed to serve a single pool. The great length and breadth of the producing area and the tremendous volume of crude oil handled daily have required the laying of thousands of miles of lines. There are approximately 10,150 wells in the field and daily production in excess of 1,000,000 bbl. for a time recently was not uncommon. Besides gathering systems for major trunk lines leaving the field, there are the transporting systems for numerous tank car racks, lines supplying 50 refineries and additional lines to steel storage tanks.

While the problem of designing an efficient gathering system must be solved for each individual lease, there are two fundamental requirements to be met if best results are to be obtained. These are: (1) In the majority of cases it is necessary that provision be made to obtain individual well gauges and the gathering system should be laid out with this idea in mind. (2) In so far as it is practicable the gathering system should be installed so that the oil is moved by gravity.

The flow of oil from a producing well, after passing through the gas trap, is run into flow tanks. In East Texas these flow tanks are on the average from 50 to 500 bbl. in size, with some tanks as great as 5000 bbl. in capacity. The flow tanks are placed in the vicinity of the well and in such a position that the flow from the separator will permit the oil to gravitate into them. The rolling topography of the area is ideally suited to this economical arrangement. Most lease tanks in East Texas are located on low ground, so that the gravity system is easily possible. There are all types of tanks in use in the field — riveted, welded and bolted, a few being vapor-proof and a larger number of the gas-tight type. Vapor recovery systems, for the most part, have been employed only where the gas is being utilized by the small number of gasoline plants. The separators are operated at vacuum, or at very low pressures, so that vapors are discharged with the oil into the stock tanks in no appreciable amounts. Thus it is uneconomical to install vapor recovery systems on the tank batteries.

Except in the case of isolated wells, few in East Texas, oil is not shipped from flow tanks but from lease or stock tanks. These tanks are concentrated so as to form a central tank battery and, when so arranged, a minimum of labor is required for gauging and drawing water.

Special care is given to grading for tank locations. In order that there may be no settlement, filled ground is avoided and ample provision is made for drainage. The grade must be absolutely smooth and, as a foundation for each tank a layer of oily sand is compacted. This protects the base plates from corrosion.

All gas-tight and water-seal tank roofs are provided with relief valves. Of these, there are many types available that variously employ the correct principles of mechanical operation, fluid level, spring and weight control. They are set to operate at predetermined pressures, assuring full protection against sudden variations in pressure due to fluid level or temperature.

It is universal practice among East Texas operators to vent the gas from the stock tanks through a common vent line to a distance approximately 75 to 100 ft., where it is burned. This is particularly important when any considerable pressure is held on the separators; otherwise the high gasoline content, rendering the vapors heavier than air, causes them to settle close to the ground and, of course, to be highly inflammable.

The vent line is usually constructed of 4-in. pipe and is led off from the top of the center hatch of each tank. At the desired distance from the tanks, a bull-head tee diverts the line upward to a height of 20 feet. The horizontal line, if good practice is followed, is sloped so that any condensation will drain back into the tanks, permitting the burning of the vapors at the top of the riser with greater safety. Many operators place a safety screen in the riser at a point just above the bull-head tee, the function of which is to prevent return of the torch flame from the riser back to the tank in case a mixture of air and tank vapors is in combustible proportion. This can easily happen when a tank is pumped out and air enters to displace the oil.

One type of flame arrestor that is proving popular among East Texas producers is constructed with two 4-in. by 6-in. swages connected with a 6-in. flange union. Inserted between the flanges are three layers of 30-in. miner's copper gauze separated by ⅛-in. asbestos gaskets.

The riser or flow line from the separator is connected through a flange on the side of the tank just under the edge of the roof, with a hatch hole 6 in. from the flow pipe. Modern tank construction in the field calls for the walkway to be located alongside the tank about 3 ft. from the top and to extend the entire length of the battery. Thus, it is not necessary for a gauger to mount to the top of the tank; also if he should become asphyxiated and fall while gauging he naturally

A Stanolind tank battery in East Texas. Note vent line hook-up

falls on the walkway away from the gauge hatch and out into the open air.

Other batteries are used, different in construction and design, with pipe connections, vent lines, etc., installed to conform to the idea of the engineer or the superintendent, but the fundamental principle is as described.

The most common header manifold is constructed of 4-in. pipe. Some companies design their manifolds so that paraffin scrapers may be inserted to clean the lines. The usual East Texas tank battery consists of from two to four tanks.

Paraffin accumulation has been experienced to a considerable degree in East Texas lease tanks. The rate of accumulation was watched over a 24-hour period on six tanks in the Kilgore area, in which the wells were flowing on choke.[1] Table I gives an idea of this rate, which indicates an average of ½ in. for each tank that was run.

TABLE I

	FIRST INSPECTION			SECOND INSPECTION		
Tanks No.	Days in Service	Tanks Run	Inches Sediment	Days in Service	Tanks Run	Inches Sediment
1	8	3	0	28	11	3
2	15	7	4	32	13	7
3	19	9	4	38	16	7
4	23	11	5	42	18	8
5	31	17	6	50	17	9
6*	28	15	12			

*Note: A new well was run into the tank when brought in, probably causing an acceleration of the deposition due to the presence of traces of water and mud.

Since the above figures were compiled, many reports of greatly increased paraffin depositions have been reported. This is natural as the field declines. Some companies have reported an accumulation of 19 in. of B.S. in stock tanks and it was composed almost entirely of clean paraffin.

Paraffin in tank bottoms should be removed or serious consequences may result: First, it is impossible to thief or gauge a tank accurately; second, large lumps of paraffin might be washed loose by flow of incoming production and be carried into the gathering lines and thus plug the pipe lines. The most common methods used for removing tank bottom deposits consist of the removal of the B.S. plate and scraping either with hand tools or by steaming. After the bottoms are scraped the paraffin is fluxed with an equal amount of fresh crude and is then pumped to the burning pit.

To obviate paraffin troubles in lease tanks many companies are installing a gun-barrel tank at each tank battery. All oil is run through this on the way to the stock tanks. These gun barrels are sometimes equipped with steam coils and are kept filled with salt water. The oil flow travels upward through the barrel and overflows into the lease tanks.

Chemicals have been successfully used in cleaning tank bottoms of paraffin deposits. One company has equipped its tanks with a 1-in. gas line running to the bottom of the tank. After introducing the desired amount of chemical into the tank, gas from the separator is injected through the 1-in. pipe, which agitates the contents and thoroughly mixes the chemical with the oil. After it has been rolled for about 30 to 40 minutes the tank is allowed to set for 10 to 12 hours. It has often been found that from 1 ft. to 15 in. of paraffin accumulation will have been lowered to an amount not exceeding 2 in. in thickness by this process.

Gas agitation as described above is used by several operators to prevent paraffin from accumulating in tanks. A spider made of perforated pipe connected to a gas line from the separator is laid on the bottom of the tank and the oil is rolled by the gas pressure as the tank is filled, causing any paraffin in the bottom to be disintegrated and probably partially dissolved or suspended in the oil. Such a system depends on sufficient gas pressure for rolling, as well as constant application to make it effective.

All East Texas tank batteries are equipped with ample provision for the settlement of water and B.S. by placing the discharge opening at a sufficient height above the bottom of the tank. Water, sand and B.S. are drawn off through the clean-out line before the tank is shipped.

Pipe line gathering systems, if properly laid out, should return a maximum of uninterrupted service at a minimum construction and operating cost. The building of an ideal network of lines requires thorough planning, especially in such huge fields as East Texas. Generally speaking, East Texas has a topography that is ideally adaptable to the building of gravity systems, and all gathering systems are at least of the semi-gravity type. The topography of East Texas consists of numerous creeks dividing the area into a series of rolling hills having a general slope from north to south over the producing area. It has therefore been relatively simple, by laying the lines in the creek beds, to gravitate oil to a few central points.

All pipe line companies operating in the district have taken full advantage of the topography. Upon decision to build gathering lines in the field, close and careful surveys of the terrain have been made and the course of each creek and location of every low spot has been mapped. Thus, we find that most of East Texas' huge oil production is gathered by gravitation and then pumped, if necessary, to the main transportation lines.

Because of the great volume of crude oil produced daily it has been necessary to speed the movement of oil through the lines. As a result, portable and semi-portable pumping units are used abundantly at the present time. This has permitted

[1] "Paraffin Troubles and Their Prevention," by W. T. Doherty and R. C. Buchan, A.P.I. Southwestern District Meeting, Tyler, Texas, April 14, 1932.

the construction of gathering lines with smaller diameter pipe and with pressure lines the oil is moved more rapidly and greater quantities may be handled. Thus only a few of the lines are at present dependent wholly upon gravity to move the oil.

Pumping units in use are of both the reciprocating and centrifugal type. Usually the pumps and power units are delivered mounted on steel skids so designed that when the pump and power are hooked up at a 90-deg. angle they form a very compact unit. The skids ordinarily consist of 8-in. channel-iron. Where the units will have a fairly long operating life at one location, a more permanent foundation is made. A channel large enough to accommodate the sills is dug and set in the ground. The steel skids to which the pump unit is bolted are set upon this sill. In other installations the ends of the units have been set on concrete poured in the channels.

A great many of the units are housed in small, quickly-erected sheet-metal buildings to protect them from the weather. In some of these a fire wall is used to separate the pump and power unit. Where this is done the units are usually set on a permanent foundation. On the open type installations, about the only provision made is a housing for the belting when it is used for transmission of power.

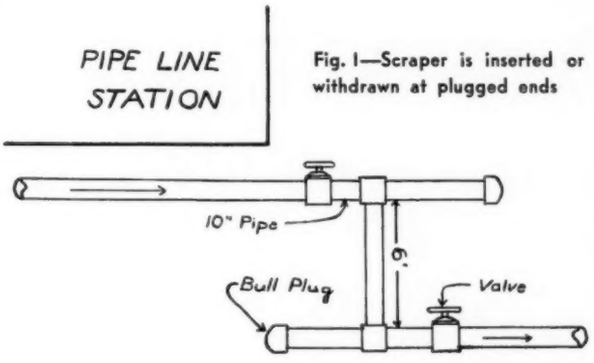


Fig. 1—Scraper is inserted or withdrawn at plugged ends

Where only one pumping unit is required, the piping layout is very simple. On such installations the gathering line is tied into the end of the tank battery header, the pumping unit is located close to the battery and a line from the tanks travels directly to the pump. The pump discharge line goes directly to the gathering system. A divider gate is set in the gathering line between the pump suction and discharge lines. A check valve is installed on each discharge line downstream from the gate valve. In the event that two pumping units are required it is common practice to use virtually the same valve control layout, whereby the line coming from the tank battery ties into a header from two suction lines, one to each pump. The discharge lines also tie into a common header and lead to the gathering line through a single pipe.

Many of the companies have so installed and connected the suction and discharge lines that it is possible to pump either way. This is especially advantageous whenever a break occurs on the line, as it enables the company to pump the fluid in the line back into the tanks and thus avoid loss of a considerable amount of oil.

Gathering pumps and power units have a high salvage value and, for economical reasons, pipe line companies have designed their gathering systems so that when the production of the field has reached a settled basis several of the local booster stations may be eliminated and the advantages of the gravity system will then be realized to the fullest extent. This action cannot be taken until the output of the field is materially lower than its present high daily recovery.

There are two general systems in use in East Texas. The local names applied to them are the "up-creek" and "down-creek" systems. By the up-creek system pump stations are erected toward the head of the creek while in the down-creek method the stations are located farther downstream. The up-creek system, which necessarily requires more pump stations, permits the handling of more oil through smaller diameter lines. Later, however, many of the stations will be removed. The down-creek system employs the gravity system to central stations, with the exception that portable pumps are used to increase the movement and to draw the oil out of low spots.

One major company using the down-creek system has divided the field into various areas, according to the elevation. The lowest spots are known as "low-gravity areas" and the high as "high-gravity areas." These are then divided into various regions, each under the supervision of a man. With this system in force portable pumps may be used to build up peak conditions whenever desired. Runs from the districts are usually taken on different days, so that pumps may be concentrated in the low-lying areas whenever necessary.

The majority of the main gathering lines in East Texas are 8-in. and 10-in., while the branch main piping systems are usually constructed of 6-in. pipe and all laterals are of 4-in. pipe. There are various types of joints in use, including screwed, welded and coupled lines.

Little difficulty has been experienced by pipe line companies in handling East Texas oil. Sometimes the lines have become choked up and the flow has been restricted due to the presence of paraffin. However, it appears that when close watch is maintained to see that all tank bottoms are in proper condition before running the oil that there will be little trouble. One company, with 300 miles of gathering lines, found that there was only a ¼-in. coating of paraffin in two years' time, but this company has been very careful in running oil from tanks. Some companies plan to run scrapers three times a year. Most of the pipe line organizations have provided special means by which paraffin scrapers may be inserted or ejected from the pipe. A common method is shown in Fig. 1. The scraper passes into the bull-plugged end of the pipe and is removed or injected at this point.

Practically all operators of the larger gathering systems in the field use strainers to prevent passage of foreign matter. These are frequently placed at station storage tanks. All crude pumped first passes through the strainer on the suction line.

Gauging and pumping methods are mainly dependent upon the number of wells and the volume of production. In East Texas, with its numerous wells and vast producing acreage, a large personnel is required to handle such work and shipments are usually made from various tank batteries every two or three days.

Gauging field tanks for shipment is a highly important operation as the company revenue is directly affected. Pipe line gaugers in East Texas make three gauges and take the average. They also take an average bottom sample, which is heated to 100 deg. fahr. in testing. The average temperature of the oil in the tanks at the present time is about 84 deg. fahrenheit.

The rapid rate of crude withdrawal in the East Texas field has caused the operators in the region to be confronted with the problem of adapting artificial means of lifting the oil to the surface. As the field continues to decline it is to be expected that several important changes will be made in the gathering systems. It is probable some of the intermediate gathering system stations will be removed within the year. The most important problem facing pipe line companies in the immediate future is the one of increased paraffin accumulations. It is natural to anticipate enlarged deposits of paraffin in tank batteries as the field becomes older and this problem may become an acute one during the approaching winter months.

Solving Well Pumping Equipment Problems

ARTICLE IV

MOTORS and ENGINES

By HYMAN LEEDEN

Engineer-in-Charge, Western Division, The Falk Corporation, Milwaukee, Wis.

SOME form of prime mover is necessary to operate the pump that lifts the oil from the reservoir to the surface. Profit in arranging a pump for slow-speed, long-stroke and continuous operation, may be offset by losses due to the inefficiency of the prime mover itself. Steam engines of the reciprocating type or of the turbine type, internal combustion engines, such as either slow-speed or high-speed gas or Diesel engines, or electric motors of the oil well, squirrel cage, Y Delta (YΔ) or Y Delta internal Delta (YΔΔ) type may be used. The selection of the type of prime mover depends on a number of factors that vary with time and place.

Where electric power is cheap, 1 cent per kw-hr. or less, and the horsepower requirements are low, 5 hp. or less, the electric motor seems to be the most desirable selection. Where power rates are high, natural gas available at low cost, and the horsepower required heavy, the slow-speed shadow ranges, however, where the selection depends on individual figures and preferences, where the final balance is struck between price of equipment, cost of repairs, maintenance, depreciation, power bills and other items usually taken into account.

Electric Motor. Within certain limitations higher efficiencies and higher power factor are obtained from motors operating on the higher speeds. The same factors are, likewise, affected by the rating of the motor. The higher the ratio of the power used to the power rating, the greater will be the efficiency and power factor, and the lower the first cost.

An actual load of 4 hp. may be delivered by an electric motor of 5-hp. rating, or by one of 25-hp. rating. The ratio will be 80 per cent on the 5-hp. and 16 per cent on the 25-hp. motor. If a 25-hp. motor is used, there will be a large reserve capacity for other operations that may be necessary. This reserve will be paid for by lower power factor, lower efficiency and higher initial investment.

If the motor to be used will be called upon not only to pump the well, but to operate the hoist, sand reel, bull wheel and other equipment, certain compromises will be necessary in speed, size and operating characteristics. The oil well motor is usually the selection for such work. Where, however, auxiliary operations can be performed by portable pulling equipment, and where the load on the well will be fairly stable, an ordinary squirrel cage electric motor can be used, which will give the highest possible power factor and efficiency and the least possible first cost.

Where some compromise can be made between these two extremes, the YΔ motor or its successor, the YΔΔ motor, finds a useful application; with their double, or triple, power ratings, all at the same speed, it is possible to select a good operating speed, (1200 to 1800 r.p.m.) and to operate a well at or near one of the two or three ratings that gives a good power factor and efficiency. By switching from one rating to another, it is possible to operate the hoist within certain limits.

In East Texas, where the daily allowable well production was 70 bbl. in April, 1932, then dropped to 37 bbl., but may rise to as much as 1000 bbl. per day if legal restrictions are removed, a motor of wide capacity seems to be desired, and a 1200-r.p.m. 9/15/25-hp., or a 15/25/40-hp. YΔΔ motor may be selected. In certain California fields, where it is known that the production will never be greater than 70 bbl. per day, and where many wells are limited to a production of from 10 to 50 bbl. per day, an ordinary squirrel cage motor, operating at 1800 r.p.m., seems to be the favorite, the proper size motor being selected for each well, in accordance with the volume of fluid that can be pumped.

Regardless of the type of motor selected it is desirable in each case to check the actual power requirements of the well, and to select a type of motor the rating of which will, as nearly as possible, approximate that of the actual power that will be required. It is also highly important in the case of electric motors that they be operated for 24-hr./day periods. The usual power company schedule consists of three parts:

(1) An energy charge based on actual amount of energy used;

(2) A reservation or demand charge, based either on the

TABLE 28

Variation of Pumping Costs With Type and Size of Motor

Size Motor hp.	Type Motor	Hp. Output	Power Input kw.	Motor Eff. %	Power Factor %	Power Input hp.	Total Energy /Mth.	Energy Charge 8c/ kw-hr.	Demand Charge $1.75/ kw-hr.	Power Factor Charge 85% Std.	Total Power Bill/ Mth.	Cost Per Bbl.
75	Sq. Cg.	5.18	7.03	55	35	9.43	5070	$40.55	$12.30	$17.50	$70.30	3.36c
25/55	Oilfield	5.18	5.52	70	38	7.40	3980	31.85	9.66	11.94	53.45	2.54
40	Sq. Cg.	5.18	6.45	60	50	8.65	4650	37.20	11.30	7.90	56.40	2.69
15/35	Oilfield	5.18	5.06	77½	44	6.79	3650	29.20	8.85	8.25	46.30	2.21
15/40	YΔ...	5.18	5.08	76	82	6.82	3665	29.30	8.90	.....	38.20	1.84
9/15/25	YΔΔ.	5.18	4.45	87	86	5.96	3210	25.70	7.80	.....	33.50	1.59

TABLE 29

Variation of Pumping Costs With Pumping Speeds and Strokes

Prod. per Day Bbl.	Speed s.p.m.	Length Stroke in.	Av. hp. Required	Gas Engine Cost—40 hp. 150 r.p.m.					Cost per Bbl.
				Invest.	Fuel	Lube Oil	Repairs	Net Cost per Mth.	
70	23.3	24	15.8	$14.00	$18.90	$ 8.00	$ 0.96	$41.38	1.98c
70	9.8	34	7.1	14.00	9.60	8.00	0.96	32.56	1.55
70	5.7	44	5.18	14.00	7.70	8.00	0.96	30.66	1.46
70	4.0	54	4.41	14.00	5.70	8.00	0.96	28.66	1.37
70	3.1	64	4.02	14.00	4.80	8.00	0.96	27.76	1.32
70	2.5	74	3.74	14.00	4.50	8.00	0.96	27.46	1.31

TABLE 30

Variation of Pumping Costs With Speed, Stroke and Equipment

Prod. per Day Bbl.	Prod. per Mth. Bbl.	Speed s.p.m.	Length Stroke in.	Pumping Cost			
				Equipment	Engine	Total per Mth.	Per Bbl.
70	2100	23.3	24	$18.00	$41 86	$59.86	2.85c
70	2100	9.8	34	23.00	32.56	55.56	2.64
70	2100	5.7	44	30.00	30.66	60.66	2.89
70	2100	4.0	54	40.00	28.66	68.66	3.28
70	2100	3.1	64	45.00	27.76	72.76	3.47
70	2100	2.5	74	55.00	27.46	82.46	3.92

size of motor selected, or on the maximum kw. demand over a short period;

(3) A power factor charge, which provides either a bonus or a penalty if the power factor varies from the predetermined standard.

Demand and power factor charges operate over 24 hours. Energy charge operates only during the time that the motor is running. Assuming that the total energy required to lift the oil will be the same over a short period as over a 24-hr. day, the net power cost per bbl. of oil lifted is bound to be lower if pumping is continued during the full 24 hours.

An illustration of the effect of motor choice on power bill is seen in a study of the East Texas condition: 3500-ft. depth, 2½-in. tubing, 2¼-in. pump, ¾-in. rods, 30-deg. to 40-deg. gravity oil, 70 to 75 bbl. per day.

Assume that the pump itself is operating under the most favorable condition of 44-in. stroke, 5.7 s.p.m., with suitable equipment. The average horsepower required to pump has been found from the power chart to be 5.18. However, it is desired to provide a reserve up to 25 hp. so that the volume of production can be increased later. It is also necessary to provide a reserve up to 75 hp. for occasional drilling operations. This can be done in the following ways:

A. Use one motor for all operations, either

(1) A 75-hp. squirrel cage motor; or

(2) A 25/50-hp. oil field motor, pumping from the 25-hp., 600-r.p.m. side, and drilling from the 50-hp. side.

B. Have one 75-hp. squirrel cage motor that can be moved from well to well for the occasional drilling operations, but pump with an individual motor at each well, using

(3) A 25-hp. squirrel cage motor

(4) A 15/35-hp. 600/1200-r.p.m. oil field motor

(5) A 15/40-hp. YΔ motor

(6) A 9/15/25-hp. YΔΔ motor.

Other combinations are possible, but these are sufficient to show the trend of power costs.

Table 28 lists each motor, and with it the accompanying power factor, efficiency, demand charge, energy charge and total power cost per month. For comparison purposes assume the power required (from chart) as being the motor output.

Energy costs are assumed as an average of 8 cents/kw-hr. Demand charge is $1.75/kw-hr. of maximum demand. Power factor charge is based on a permissible power factor of 85 per cent. It should not be overlooked that the power estimates are based on an assumption of most favorable pump conditions; under other conditions it will be higher.

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TABLE 31

Variation of Pumping Costs With Maximum Volume and Speed

Speed s.p.m.	Length Stroke in.	Production—Bbl.		Hp. Required	Engine Speed r.p.m.	Engine Cost—40 Hp. Engine					Cost		
		Per Day	Per Mth.			Am. Invest.	Fuel	Lube Oil	Repairs	Total	Am. Equip.	Total per Mth.	Per Bbl.
25	24	182	2,460	17.7	150	$14.00	$20.20	$ 8.00	$ 0.96	$43.16	$18.00	$61.16	2.48c
25	34	235	7,050	24.3	150	14.00	25.40	8.00	0.96	48.36	23.00	71.36	1.01
25	44	386	11,580	32.6	160	14.00	32.60	8.30	1.02	55.92	30.00	85.92	.75
25	54	540	16,200	40.0	200	14.00	40.00	9.70	1.28	64.98	40.00	104.98	.65
25	64	693	20,790	47.3	230	14.00	47.30	10.80	1.46	73.56	45.00	118.56	.57
25	74	845	25,350	54.8	280	14.00	54.80	12.60	1.78	83.18	55.00	138.18	.55

TABLE 32

Variation of Pumping Costs With Intermittent Pumping

Production		Speed s.p.m.	Hrs. per Day	Hp. Required	Gas Engine Cost—40 Hp.—150 r.p.m.					Cost per Bbl.
Per Day	Per Month				Am. Invest.	Fuel	Lube Oil	Reapirs	Total per Mth.	
70	2100	20	5.9	23.0	$14.00	$ 5.95	$ 8.00	$ 0.96	$28.91	1.38c
70	2100	15	8.4	15.50	14.00	6.48	8.00	.96	29.44	1.40
70	2100	10	13.4	9.55	14.00	6.65	8.00	.96	29.61	1.41
70	2100	5.7	24.0	5.18	14.00	7.70	8.00	.96	30.66	1.46

TABLE 33

Variation of Pumping Costs With Type of Transmission

Type of Transmission	Hp. to Polished Rod	Hp. Output of Engine	Engine Cost, 40-Hp.—150 r.p.m.				Cost	
			Inv.	Fuel	Lube Oil	Repairs	Total per Mth.	Per Bbl.
Belt (Double)	5.18	14.80	$14.00	$17.30	$ 8.00	$ 0.96	$40.26	$1.92c
Worm Gear (Single)	5.18	12.95	14.00	15.40	8.00	.96	38.36	1.83
Chain (Triple)	5.18	10.35	14.00	12.90	8.00	.96	35.86	1.71
Spur Gear (Double)	5.18	8.62	14.00	11.00	8.00	.96	33.96	1.62
Herringbone Gear and V-Belt	5.18	6.92	14.00	9.00	8.00	.96	31.96	1.52

TABLE 34

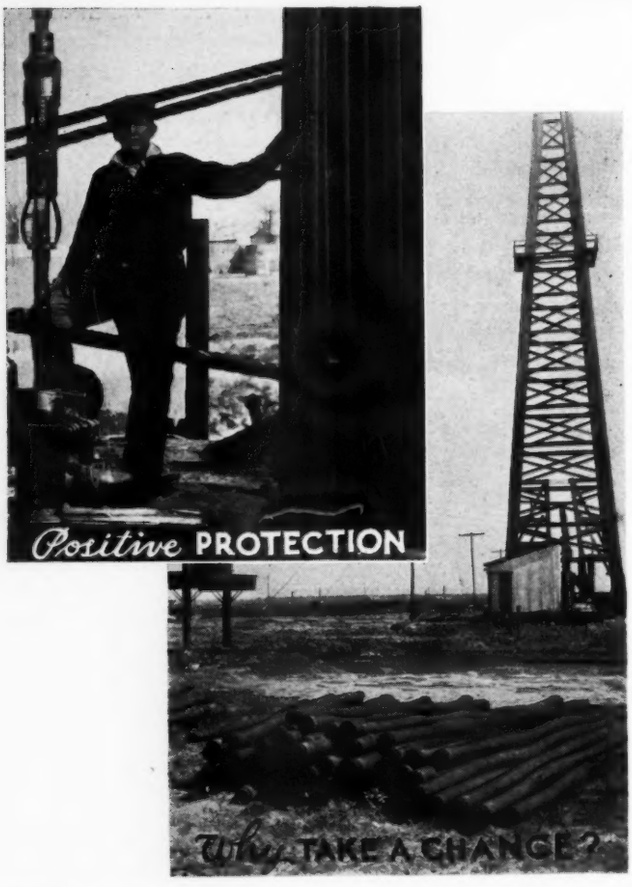
Variation of Pumping Costs With Type and Size of Engine

Engine Hp.	Pumping Speed s.p.m.	Engine Speed r.p.m.	Production		Hp. Required	Engine Costs				Total Cost	
			Per Day Bbl.	Per Mth. Bbl.		Inv.	Fuel	Lube Oil	Repairs	Per Mth.	Per Bbl.
10	5.7	200	70	2100	5.18	$ 4.50	$ 4.09	$ 2.15	$ 0.40	$11.14	0.53c
15/17	5.7	130	70	2100	5.18	5.50	4.09	1.70	.34	11.63	0.55
20/25	5.7	120	70	2100	5.18	8.50	4.63	2.25	.47	15.85	0.75
30	5.7	120	70	2100	5.18	12.00	6.45	4.20	.56	23.21	1.11
40	5.7	120	70	2100	5.18	14.00	7.40	6.80	.77	28.97	1.38

TABLE 35

Variation of Pumping Costs at Maximum Production

Engine Hp.	Pumping Speed s.p.m.	Engine Speed r.p.m.	Production		Hp. Required	Engine Costs				Total Cost	
			Per Day Bbl.	Per Mth. Bbl.		Inv.	Fuel	Lube Oil	Repairs	Per Mth.	Per Bbl.
10	11.4	400	147	4,410	9.6	$ 4.50	$ 7.85	$ 4.50	$ 0.80	$17.65	0.40c
15/17	17.5	400	240	7,200	17.2	5.50	13.60	5.50	1.00	25.60	0.35
20/25	23	400	343	10,290	25.0	8.50	19.80	7.00	1.58	36.88	0.36
30	30	250	510	15,300	35.0	12.00	35.00	7.80	1.40	56.20	0.37
40	30	160	510	15,300	35.0	14.00	35.00	8.30	1.02	58.32	0.38



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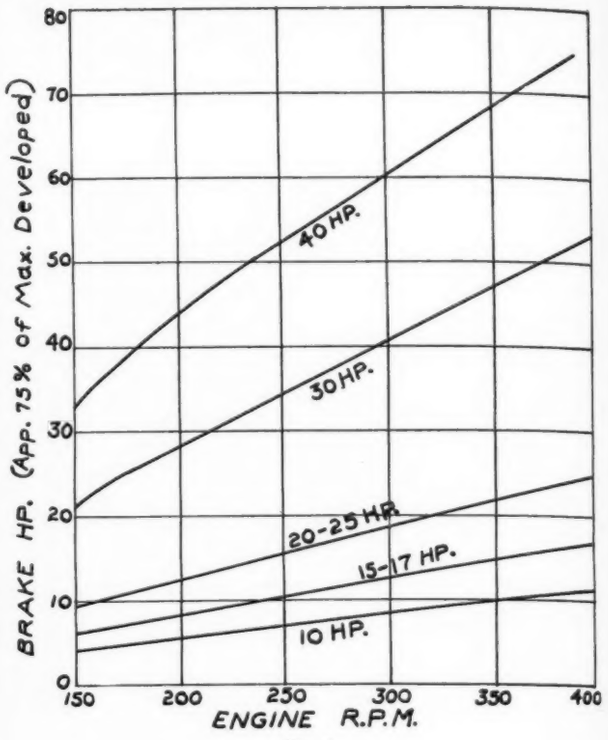


Fig. 2

bustion engine used for oil field work is the slow-speed single-cylinder, 40-hp. gas engine. This is due to a number of reasons, among which three are outstanding: (1) Most oil fields have available large volumes of natural gas at little or no cost. (2) The prevalence for many years of pumping speeds ranging from 20 to 30 s.p.m., and the standard rig front transmissions limited to maximum belt ratio of 8 to 1, automatically led to gas engine speeds of 150 to 200 r.p.m. (3) The necessity of both servicing and pumping the well with the same equipment made imperative the use of engines capable of developing sufficient horsepower.

Natural gas is still available in many fields, but the natural

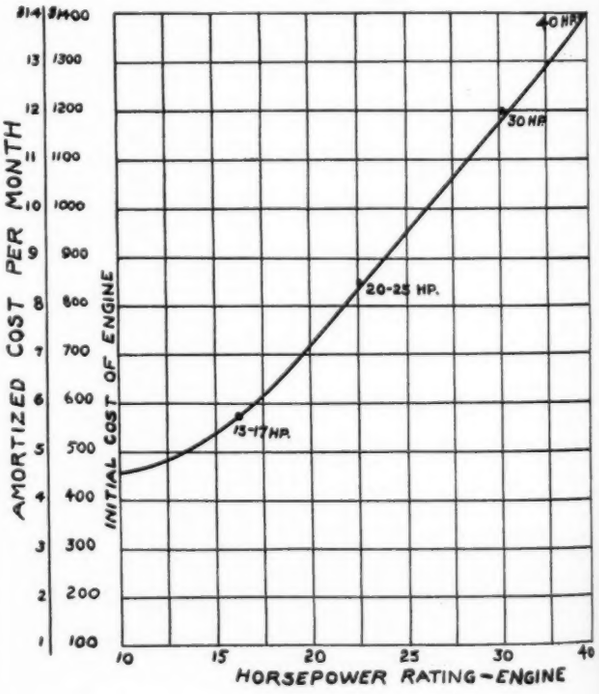
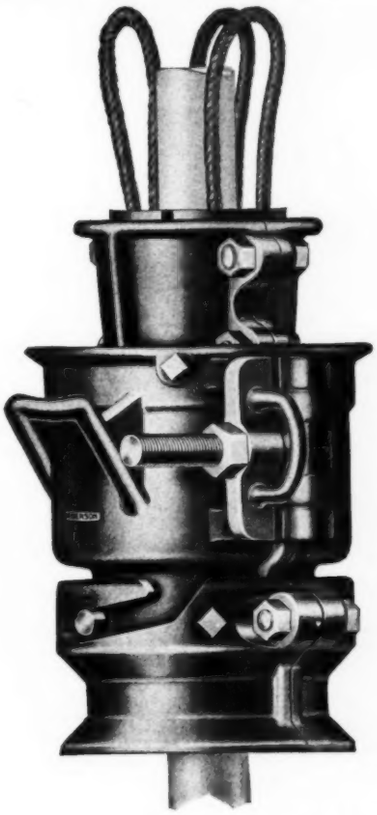


Fig. 3



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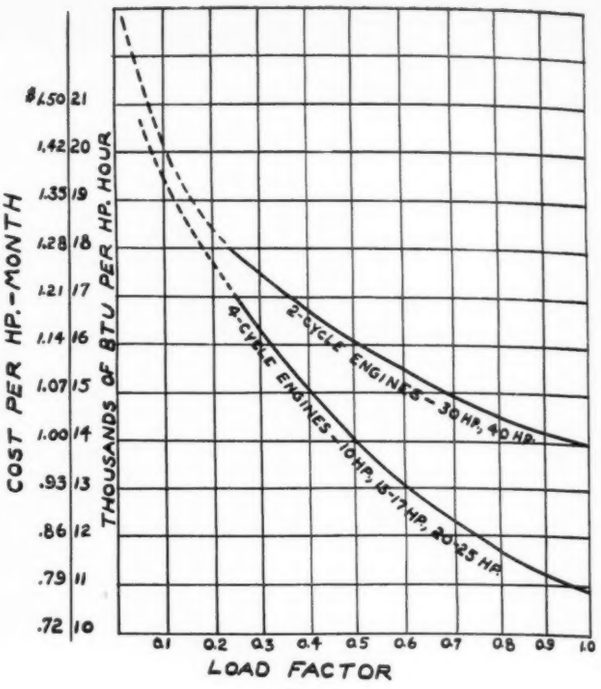

Fig. 4

and legal limitations on production, together with the introduction of improved transmissions and portable servicing machinery, have led to a reconsideration of the equipment and methods that may be used. Today it is quite as important to operate the pump efficiently with an internal combustion engine as with an electric motor, but the conditions for efficient operation are not so easily determined. There are no rigid or published power cost schedules available for engines nor are exact horsepower outputs of engines easily measured. However, some inkling of the variation of pumping costs under different conditions may be obtained from a study comparable to that made with the electric motor.

Principal costs of operating with internal combustion engines are: (1) investment; (2) fuel; (3) lubricating oil, and (4) repairs. To this should be added labor and attendance on the lease, but as this item fluctuates highly with location and producer, and as it occurs also with the electric motor, it is not included in the calculations. Figures used for the study were obtained from a leading engine manufacturer and are as correct as any such figures may be under the highly variable conditions encountered. Engines made by other manufacturers would naturally show deviations in first cost, fuel consumption, lubricating oil and repair costs, but such deviations would affect only the magnitude of the amounts and not the nature of the trend.

Fig. 2 shows the horsepower that is developed and may safely be used by various engines at speeds ranging from 150 to 400 r.p.m. This is about 75 per cent of the maximum developed horsepower as shown on the A.P.I. curve.

Fig. 3 shows the initial cost of these engines. Allowing for fixed charges, such as depreciation, interest, taxes, etc., at the rate of 1 per cent per month, it gives also the amortized cost per month.

Fig. 4 shows the fuel consumption in B.t.u./hp.-hr. and the cost per month, assuming 1000 B.t.u./cu. ft. of gas, a fuel cost of 10 cents per thousand cu. ft., and 720 hr. per month operation.

F.g. 5 shows the cost of lubricating oil consumption for the several engines at speeds of 150 to 400 r.p.m., based on oil at 40 cents per gallon.

Fig. 6 shows the cost of repairs of the more modern engines, based on 2 per cent of the equipment cost per year at

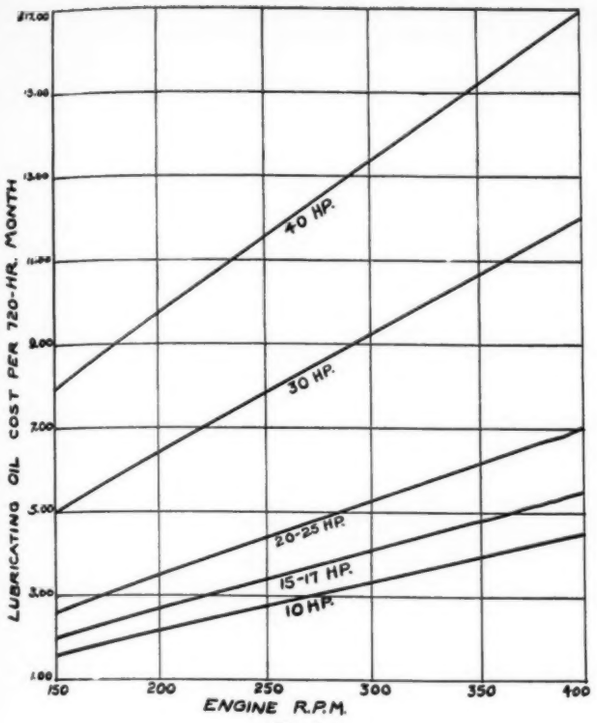

Fig. 5

rated speed. This is perhaps the most disputable item, as it was higher on older engines and may be reduced on improved engines. However, it is sufficient for study purposes.

With these figures it is possible to prepare tables similar to those used in the electric motor study for pumping wells in a field such as East Texas: 3500-ft. depth, 2½-in. tubing, 2¼-in. plunger, ¾-in. rods.

Table 29 corresponds to Table 18, and shows the variations of pumping costs with pumping speeds and strokes for a production of 70 bbl./24-hr. day. Investment is the amortized cost from Fig. 3. Fuel is taken from Fig. 4 and is equal to: cost per hp.-month (at load factor in operation and type of engine) × hp. used. Lube oil and repairs are taken from Figs. 5 and 6, respectively, and are based on an engine speed of 150 s.p.m., as at this speed sufficient hp. can be developed for all six operating conditions.

It is evident that with gas engines, as with motors, the cost of pumping 70 bbl./day declines as the stroke is lengthened and the speed reduced. However, as with motors, the saving of fuel, etc., should be checked against increased amount of equipment.

Table 30 corresponds to Table 19, and shows the variation of pumping costs when equipment is included in the consideration. Amortized cost of equipment is taken from Table 19 and engine operation cost is taken from Table 29.

As with electric motors, the greatest net economy is obtained at neither extreme of stroke-speed combination. In this case the "happy medium" seems to be at 34-in. stroke, 9.8 s.p.m., or very nearly the same as with electric motor (44-in. stroke 5.7 s.p.m.) It may, however, be necessary to go to larger equipment, or to provide for higher speeds, or both, at a late date if production of more than 70 bbl./day is anticipated. In such case present economy may have to be sacrificed for the sake of future requirements.

Table 31 corresponds to Table 20 and shows the costs obtained when the equipment in each case is set to give maximum production at maximum speed. Production and equipment data are taken from Table 20. Engine cost data are computed from Figs. 3 to 6, inclusive, as in Table 29.

Again we have a continually declining cost per bbl. of fluid lifted with the larger equipment. If heavier production

PRODUCTS for pumping wells
The KEY to LOWER LIFTING COSTS
CORRECTLY DESIGNED • • ECONOMICALLY PRODUCED
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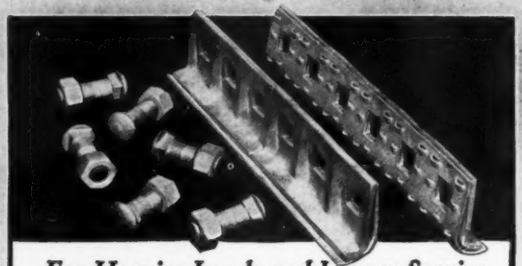

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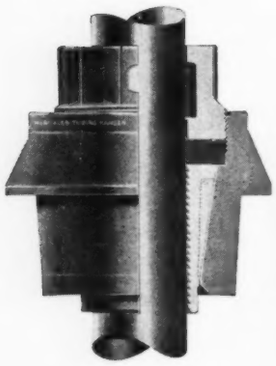

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The Hercules Tubing Anchor—a bottom hole tubing support—anchors the tubing at any point within the casing.

The use of these two tools assures 100% Safety to a string of tubing.

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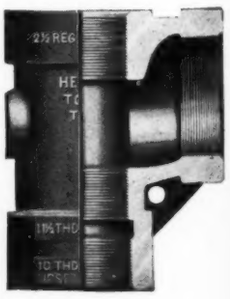

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can be anticipated at an early date it may be found more profitable to install heavier equipment at a sacrifice of immediate economy.

Tables 29, 30 and 31 assumed continuous 24-hr./day pumping. It is possible, however, as with the electric motor, to select the most desirable stroke length and equipment, but pumping at intermittent periods depending on the pumping speed. Table 32 corresponds to Table 23 and shows the variation of gas engine pumping costs at intermittent periods. As the same equipment is used in all cases, equipment costs are not included.

Contrary to the electric motor conditions, there is little or nothing to be gained by going to continuous rather than intermittent pumping, when using a 40-hp. engine for such limited production. When required man-power is taken into account the single shift operation may prove to be the most desirable.

In Tables 29, 30, 31, and 32, the calculations are based on power required as taken from production and power charts, which will be reproduced in a later article. These, however, are merely average values and are found to vary considerably with the type of transmission used. Assuming that the pump will be operated at what seems to be the most desirable condition of 44-in. stroke and 5.7 s.p.m., taking the power from the chart as being that required at the polished rod, and using the efficiencies of transmitting equipment as those in Table 26 (not strictly true because they include motor losses), we get the lifting costs as given in Table 33. This table corresponds to Table 27 in the electric motor data.

Let us assume again that we have to pump 70 bbl. per day in a field like East Texas; and that we have found the more desirable condition to be 44-in. stroke 5.7 s.pm., but we wish to provide for increased production in the future with the same equipment. Present requirements can be taken care of by any of the five engines listed—10-hp., 15-hp., 20/25-hp., 30-hp., or 40-hp. Future requirements, however, will depend on the fluid to be lifted.

Table 34 shows the variation of pumping costs with selection of gas engine for present 70 bbl./day conditions. Table 35 shows the costs that may be expected where each engine is developing the increased power that higher speeds and larger production require. Higher pumping speeds are obtained by increasing the engine speed to 400 r.p.m.

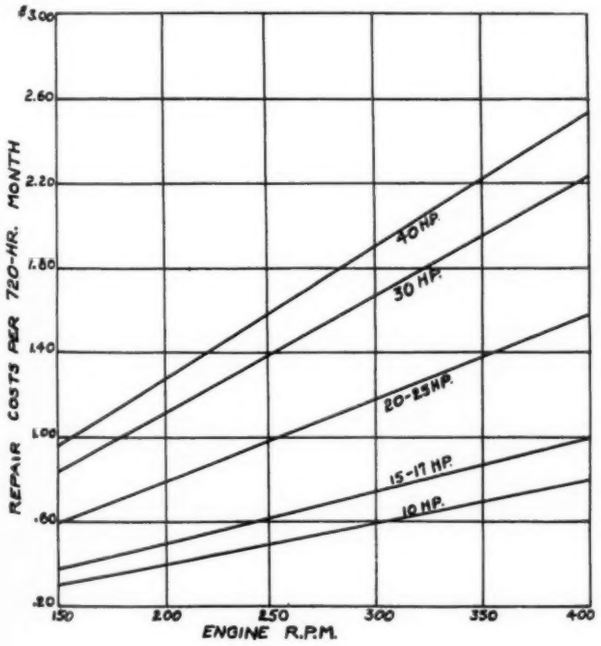

Fig. 6

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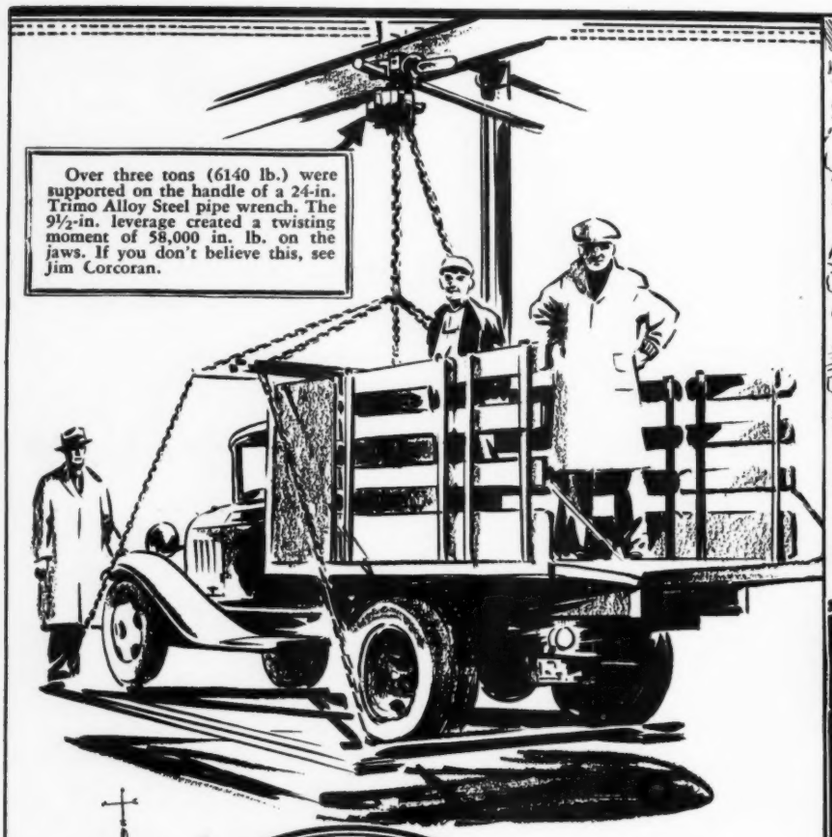
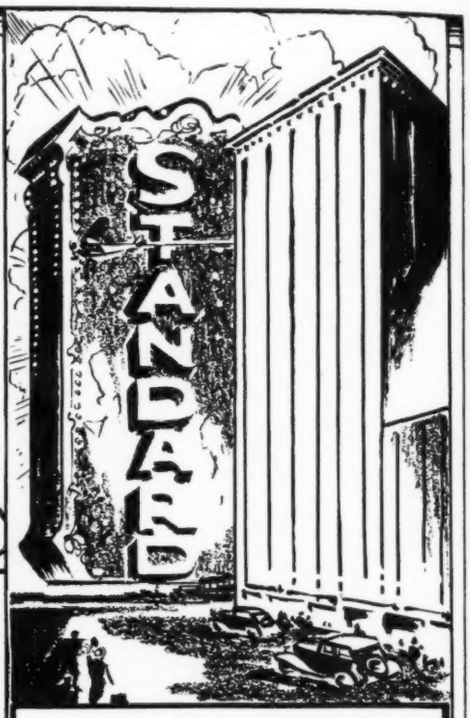
STRANGE.... *but* TRUE

HAPPENINGS IN THE PETROLEUM INDUSTRY



Over three tons (6140 lb.) were supported on the handle of a 24-in. Trimo Alloy Steel pipe wrench. The 9½-in. leverage created a twisting moment of 58,000 in. lb. on the jaws. If you don't believe this, see Jim Corcoran.



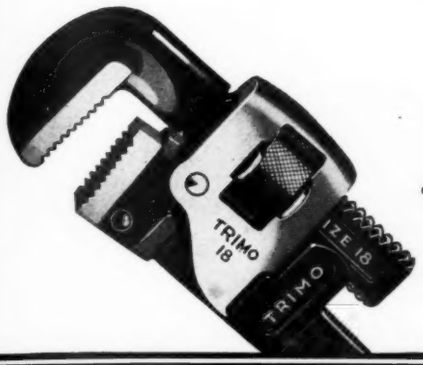
An electric sign equal in height to that of a 14-story building and a length of half an ordinary city block is being built in Chicago by the Standard Oil Company of Indiana. It has a total weight of 80 tons, while the supporting structure weighs 120 tons. More than 8000 incandescent lights and half a mile of Neon tubing will flash on 32 separate sequences.

The newest use known for oil company water reservoirs in West Texas is as a baptismal fount. A pool near Wink was used recently to baptize 49 new church members.

Excluding producers' tax, a total of about 75 cents per bbl. is paid in taxes by the general public; or 750 per cent when East Texas oil is selling for 10 cents and 300 per cent when crude produced in this region is bringing 25 cents per barrel.

Buy Strength!

That's what your good money must secure if you want full value in a pipe wrench. No finer, stronger, safer wrench can be found than all-steel Trimo.



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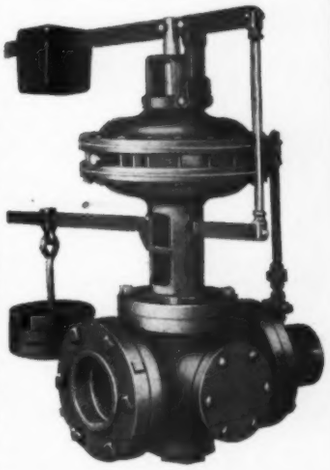

THE same sensitiveness of regulation that has been available for low gas pressures can now be applied to medium pressures as well. The Fulton Duplex Medium Pressure Regulator, patterned after the C-F Duplex Low Pressure Regulator, employs two levers connected in such a manner as to multiply the force exerted on the diaphragm several times. Designed for inlet pressures of 50 to 100 pounds, outlet pressures 5 to 10 pounds. Ask for complete description.

The Chaplin-Fulton Mfg. Company
28-40 Penn Ave. Pittsburgh, Pa.

FULTON DUPLEX
MEDIUM PRESSURE REGULATOR

Packings *for* Reciprocating Rods

Impervious *to* Gasoline

No Lubricants Required

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The M. M. Kinley Company was called on last July, by the Tulsa Oil Company, to extinguish this big fire at Overton, Texas. The well was making 20,000 barrels of oil. The fire was successfully extinguished by shooting.

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Thomas F. Lydon Dies

THOMAS F. LYDON

THOMAS P. LYDON, executive vice president and treasurer of Shell Petroleum Corporation, died Sunday, June 4, at St. John's Hospital, St. Louis, Mo. Death was due to a complication of diseases following an abdominal operation to determine the cause of his illness.

Lydon, who was 57 years old, was born in Ireland, coming to St. Louis in 1893. In the same year he began his business career in the accounting department of the Missouri-Pacific railroad. In 1902, he became associated with the Waters-Pierce Oil Company, spending several years in the office at Mexico City. Later he advanced to the position of comptroller. He joined the Roxana Petroleum Corporation, predecessor to Shell Petroleum Corporation at Tulsa, Okla., in 1916, as secretary and was named vice-president and treasurer for Shell in St. Louis in 1923.

Of primary importance to Lydon, during the years in which he was a prominent figure in the oil industry, was the welfare of employees. Due largely to his efforts, the share-the-work movement was introduced in the Shell organization last year and through it the number of the corporation's employees was increased about 18 per cent.

During the Spanish-American war, Lydon served as a captain in the Missouri National Guard. He was a past commander of Walker Jennings Camp No. 4 of the United Spanish War Veterans in St. Louis, a director of the St. Louis Chamber of Commerce, and a charter member of the Missouri Athletic Association in St. Louis.

Lydon is survived by his widow, Mrs. Alice Stanley Lydon; a son, Thomas Hubert; four brothers, Martin J., Joseph P., Mathias, and John J. Laydon; two sisters, Mrs. William Nolan and Mrs. Michael Delany.

Bristol New York Office Moved

The Bristol Company, Waterbury, Conn., makers of indicating, recording and controlling instruments, announces that beginning May 1, 1933, the New York office will be located in the Daily News Building, 220 East 42nd Street. Because of its central location and easy accessibility, this new office will enable the company still more efficiently to serve its clientele throughout the metropolitan territory. C. W. Williamson, district manager, continues in charge, assisted by a staff of six application and service engineers.

Wyatt Metal Declares Dividend

Directors of the Wyatt Metal and Boiler Works, Dallas, Texas, have voted a 3 per cent dividend on $1,000,000 capital stock according to an announcement made by President W. J. Wyatt. This dividend is a reflection of the company's confidence in the immediate future business conditions of the country. The $30,000 dividend will be paid in two installments, the first on July 1 and the second October 1, representing dividends for six months.

Frank R. Foster Killed

Frank R. Foster, 41, independent oil producer and drilling contractor, was fatally injured June 7 at Atlanta, Ga., when he accidentally walked into a spinning airplane propeller upon dismounting from the plane which had just arrived at the Atlanta airport from Dallas.

Frank R. Foster

Foster, whose operations were carried on under his own name, maintained headquarters in the Tower Petroleum Building, Dallas, Texas. He was enroute to New York City to attend the Schmeling-Baer fight at the time of the accident. His body was returned to Dallas for burial.

Foster for many years had been an active wildcatter. His first operations were in the fields of south Arkansas and north Louisiana. To him goes much of the credit for the opening of the great East Texas oil field, since he participated in the drilling of the first big oil producer and important extension following the completion of the C. M. Joiner well. After the finding of several dry holes in the vicinity of the Joiner well operators in the region had become discouraged over the prospects of the field when Foster and his associates moved to the west of the original well about one mile, an area that had not previously been played. The completion of this well resulted in the first big drilling development in East Texas. Foster became an important lease owner and operator in the area and his next test provided the impetus that eventually caused it to become one of the world's largest oil fields. This was the opening of the Lathrop pool near Longview, which at that time was more than 12 miles north of production. Foster remained a faithful wildcatter to the last, having drilled several wells in Louisiana since his remarkable discoveries in East Texas.

Lufkin Reopens Houston Office

Lufkin Foundry and Machine Company, Lufkin, Texas, has reopened its Houston, Tex., office at the old location, 806 Second National Bank Building. C. B. Edwards, Gulf Coast representative for the company, is in charge.

"Eb" Isaacks Joins Kerotest

J. D. ("Eb") Isaacks has been appointed to the sales staff of the Kerotest Manufacturing Company, Pittsburgh, Pa., effective June 15. For the past seven years Isaacks has been research engineer for *The Oil Weekly* and associated papers. He will make Houston, Texas, his headquarters and will cover the active territories in connection with the sale of completely assembled and tested "Gray-Kerotest" christmas trees, etc., as well as the regular line of Kerotest valves and fittings.

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LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

A Fairy Story

When Jack reached the top of the bean stalk he looked in a window and saw the King, who was attended by three beautiful women—a blonde, a brunette, and a red-head.

Said the King to Jack: "I'll give you your choice."

Said Jack to the King: "I'll take you, King."

* * *

"I asked her for a kiss without avail."

"I don't like to kiss through those things either."

—*College Life.*

* * *

"Why was it you broke your engagement to Grace?"

"You see I only did to the engagement what it did to me."

* * *

When a man turns out the light, a girl is never in the dark about his intentions.

* * *

Jim: Do you know any one in this town?

George: Yes. I have a broad acquaintance.

Jim: Really? What's her name?

* * *

She: I've got the prettiest little niece.

He: Yes, I couldn't help but notice them.

* * *

"This liniment makes my arm smart."

"You should rub some on your head."

* * *

Judge: Do you realize you are up before me for intoxication?

Culprit: That's fine. Bring on the liquor.

* * *

Joe: Why did you run home last night?

Cora: I was being chaste.

* * *

Conductor: Your fare.

Young Thing: Oh, thank you!

* * *

A very beautiful girl was confronted with the difficulty of selecting between a rich old man or a poor young man for a husband. She took as her choice the rich old man. Shortly after the wedding, however, she decided that money wasn't all and she made the following wish:

"I wish he was as young as I or I as old as he."

No sooner had she made the wish than she felt old age creeping on.

* * *

Censor: Young lady, I object to your bathing suit.

Young Lady: I know. You men are all alike—but they wouldn't let me bathe without it.

* * *

He: Do you stuff olives here?

She: No, but I fill dates.

* * *

"You don't like to dance, do you?"

"I love to, fool!"

"Okay, we'll leave after this dance."

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